



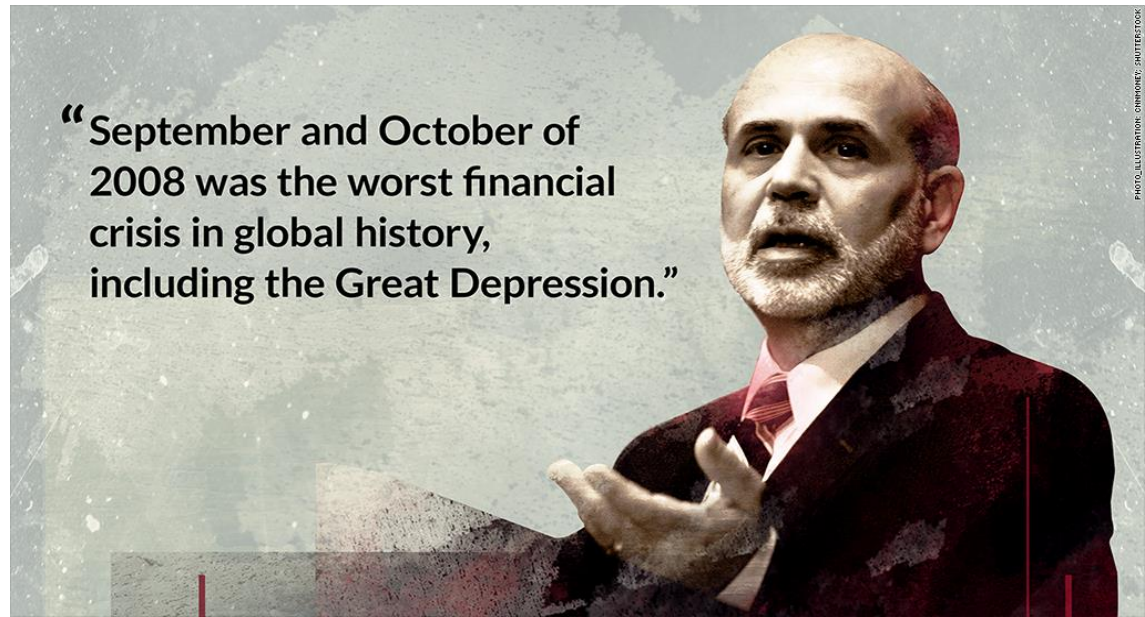
Walking on ice: Monetary policy before and after 2007

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2018

Doctoral Thesis in Economics

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([Caption](#) available on [line](#))

Biography

José Luís Seara de Morais was born in Luanda on May 10, 1953. He lived most of his youth in Angola, where he earned a degree in Economics at the School of Economics of the University of Luanda. He started his banking career, part-time, in the early 1970s (Banco Inter Unido), after making some money in sales during school vacations. He indulged in the practice of sports, such as judo, snorkeling, rowing, and skydiving. He won the Provincial (Angola) and Portugal's national rowing championships (double-skull) and the Provincial judo championships for two consecutive years.

He moved to Canada in early 1976, where three months following arrival, was invited to take a management-in-training program in the Canadian Imperial Bank of Commerce. After some six years at the retail level, he was asked to join the corporate banking area, and later, the trade finance division at the headquarters. In 1983 he was awarded the title FICB with honors (Fellow of the Institute of Canadian Bankers), following the completion of a degree in banking taken at University of Toronto and Ryerson University.

He came to Portugal in mid-1987 to join Banco Totta & Açores. In 1988, he got a degree in "Top Banking Management", a full-time co-project between IFB (Instituto de Formação Bancária) and Universidade Católica, under the supervision of Professor Ernâni Lopes. At the age of 36 he reached the top of the career in banking in Portugal, as a central director. He, subsequently, was invited to work at Banif, where he stayed for a few years. He later joined Banco Espírito Santo. Throughout these years, he had the opportunity to work in several fields, ranging from branch network management, to corporate banking, to investment banking, as well as risk management, and international banking. At the turn of the century, he enrolled, part-time, in the MSc program in Business Sciences, at the School of Economics and Management (FEP) of the University of Porto. While completing the post-graduation component, he did not hand over his thesis, which, incidentally, aimed at studying banks' assets securitization in Portugal; the very type of financial instrument closely associated with the 2007-9 debacle.

After retiring in 2010, and following a bout with health, he decided to go back to school. In 2011, he was enrolled at the Doctoral Program in Economics at FEP.

He has been married since 1974 and is the father of two sons, born in 1976 and 1984. He is blessed with two grandchildren.

Acknowledgments

I would like to thank all staff members of the School of Economics at the University of Porto. They have all contributed directly or indirectly to this Thesis project. I am particularly grateful to all the teachers who have tutored me over the last years. A particular reference should be made to Professors Antonio Brandão and Elvira Silva, who revealed enthusiasm and a particular ability to demystify complex concepts, while offering encouragement. Thank you.

A special note of gratitude to the late Professor António Almodôvar is warranted. His guidance throughout the course of History of Economic Thought helped me to confirm the choice of the Thesis' topic, as well gain a deeper understanding on the makings of monetary policy. He was a true gentleman and an outstanding scholar, who is and will be missed.

Needless to say, I am indebted to my Supervisor Ana Paula Ribeiro for the countless hours spent reviewing this work with paper and pencil. I have benefited immensely from her insightful advice over the last few years. For that invaluable contribution, I can only be forever grateful.

A reference should be made to Johannes Pfeifer. His assistance (and availability) in developing “DDGE” models and broaching the concept of time-varying parameters was particularly relevant to me. I certainly appreciate it.

A word of appreciation must be extended to my bright-minded “young” colleagues in the PhD program. Their friendship, cooperation, and kindness have helped me throughout this arduous and challenging course.

I would also like to acknowledge the counselling and motivation offered by my friends and family. Their love and patience are very important to me.

A special thanks to my wife Isabel is due. She has been my companion for several decades, in health and sickness, in good and bad times. Once more, she was there to support and encourage me, not to mention some hard work in data processing and text formatting. Thank you, dear Isabel.

Last but not least, I would like to thank and dedicate this work not only to my wife Isabel, but also my sons Pedro and Alexandre, their wives Anabela and Catarina, and my precious grandchildren Francisca and Guilherme. After all, they are the most important people in my life without whom the completion of this work would be next to impossible.

To my parents, Álvaro and Laura, and my brother João (in memoriam)

Abstract

This thesis focuses on the implementation of monetary policy before and after 2007, particularly when short-term interest rates reached the zero-lower bound.

In the first essay, we present a simple relation to capture the *joint dynamics* of the two main tools of unconventional monetary policy: large-scale asset purchases and forward guidance. When nominal short-term interest rates, hit the zero-lower bound, the existing analytical models simply failed to explain the mechanisms of unconventional monetary policy and became useless. Economists rushed to the drawing-board and produced abundant research, including models accounting *separately* for the mechanisms of both tools.

The second essay analyses empirically the pass-through effects of unconventional monetary policy conducted by the Fed spanning the period 2008-15. Use is made of an unobservable monetary policy process, whenever possible. The results, relying on daily data, suggest that these policies are effective at the zero-lower bound in lowering yields and can be disentangled into its main components: in Fed speak, quantitative and non-quantitative easing, which includes forward guidance. Moreover, monetary policy effects appear to be fairly persistent tapering off slowly.

In the third essay, we study the effects of fiscal stimuli financed through *seignorage*, particularly an increase in government spending, a tax rebate, and the issuance of “bonus checks”. A comparison is made with conventional debt-financed stimuli. The results pertaining to the first hypothesis, under appropriate calibration of nominal rigidities, suggest that there are strong effects on real economic variables, with relatively mild consequences on inflation. A complementary experiment is conducted to capture a zero-lower bound constraint, and the results suggest that an accommodative monetary policy rule, under commitment, may provide a possible adequate answer, without relying upon fiscal stimuli. Alternatively, when nominal interest rates can be pushed down to negative terrain, money-financed stimuli, may lead to positive outcomes, provided that nominal rigidities exhibit high values.

Keywords: conventional and unconventional monetary policy, central bank, financial crisis, zero-lower bound, fiscal policy, seignorage, nominal rigidities

JEL codes: C20, E32, E40, E43, E52, E62

Resumo

Esta tese estuda alguns elementos da condução da política monetária antes e depois de 2007, em particular quando as taxas de juro nominais de curto prazo alcançaram o limite mínimo zero.

No primeiro ensaio é apresentada uma relação simples que visa capturar as *dinâmicas simultâneas* relativas às duas principais ferramentas da política monetária não convencional: a compra massiva de activos financeiros e a sinalética relativa à evolução das taxas de juro de curto prazo (“*forward guidance*”). Quando as taxas de juro atingiram zero, os modelos analíticos existentes não permitiam explicar os mecanismos de funcionamento da política monetária não convencional, pelo que deixaram de ser relevantes. Na literatura surgem posteriormente vários modelos que descrevem em separado, mas não em conjunto, as dinâmicas da compra de activos e do “*forward guidance*”.

No segundo ensaio é realizado um estudo empírico relativo aos efeitos da condução da política monetária da Reserva Federal Norte-Americana, assumida, sempre que possível, como um processo não observável, sobre uma série de variáveis financeiras. O período em análise cobre os anos de 2008 a 2015. Os resultados, com base em observações diárias, indicam que as medidas de política monetária levaram a uma redução das taxas de juros (ou, equivalentemente, ao aumento de preços) das variáveis financeiras. Adicionalmente, procede-se à diferenciação entre os efeitos da compra de activos e de outras medidas que incluem “*forward guidance*”.

No terceiro trabalho estudam-se as consequências de estímulos fiscais financiados com recurso à emissão de moeda. Em particular, são considerados um aumento de gastos públicos, um corte de impostos e a emissão de “*cheques bónus*”. Procede-se também a uma comparação com os efeitos de estímulos fiscais financiados através da emissão de dívida pública. Os resultados obtidos relativos à primeira hipótese, desde que os níveis de rigidez nominal sejam suficientemente elevados, apontam para aumentos expressivos das variáveis reais, enquanto a evolução dos preços é contida. Numa experiência que visa captar explicitamente um ambiente de taxas de juro no limite mínimo de zero, obtêm-se resultados que sugerem que a aplicação de uma política monetária sob compromisso poderá ser uma solução, sem ter de recorrer a estímulos fiscais. Uma outra alternativa é permitir que as taxas de juro assumam valores negativos e, simultaneamente, efectuar estímulos fiscais financiados através da emissão de moeda. Um requisito é que os níveis de rigidez sejam altos, o que é expectável num cenário de recessão severa.

Palavras-chave: política monetária convencional e não convencional, banco central, crise financeira, limite inferior-zero, política fiscal, senhoriação, rigidez nominal

Códigos JEL: C20, E32, E40, E43, E52, E62

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Chapter 1

Introduction

Walking on ice: Monetary policy before and after 2007

Introduction

Monetary policy as implemented by most central banks in the advanced economies was subject to a severe disruption following the sub-prime crunch in the summer of 2007 and the ensuing financial crisis, which, by all accounts was the starkest since World War II. Up to this time, monetary policy consisted essentially of fixing a short-term nominal interest rate. Once, in practice, interest rates reached the zero lower bound, conventional monetary policy became useless. Central banks and policy makers were quick to undertake additional measures, such as direct credit interventions, targeted securities purchases and forward guidance on the path of the short-term nominal interest rate aiming at avoiding the collapse of the financial markets and reducing private sector borrowers' interest rates and prop up economic activity.

However, this process was not that simple; according to Smith (2016), Bernanke (2015) vividly describes it in his book "The Courage to Act". A conflict arose between certain politicians and technocrats (the Fed is a famously technocratic institution) right from inception when direct interventions were implemented. Subsequently, the cleavage accelerated following the announcement of large-scale asset purchases; this time tensions arose not only from politicians but also from some economists who feared that such measures might lead to a drastic increase in inflation and generate artificial asset bubbles. Even worse, was the attempt by some politicians to audit (further) the Fed, or advocating discredited monetary systems like the gold standard; a proposal, which ultimately failed, advanced the idea that the Fed should follow a simplistic monetary policy rule set by the Congress. These vagrancies also took place with the ECB. Recall, for instance, the difficulties encountered by Mario Draghi and his colleagues when large-scale asset purchases were promoted.

For economists the significance of these events has been a crisis of a different kind. The analytical models that had become the norm over the previous two to three decades were no longer able to explain these unusual significant events. They responded

with abundant research on these new developments and the measures undertaken, dubbed unconventional monetary policies.

The purpose of this dissertation is to make a contribution to the studies on this new unconventional monetary policy. This particular chapter serves as an introductory note to our main research topics and hopefully motivates the reader to our main points of interest by presenting them in a broad perspective. In the following chapters, we narrow down our focus and adopt a more detailed approach.

New analytical models have been studied [*e.g.*, Gertler and Karadi (2013) on the subject of large-scale asset purchases and Cardani *et al* (2017) on forward guidance], however, no model has been proposed to account for the joint dynamics of these two main policy tools. Against this background, the author puts forward in Chapter 2, an unpretentious relation between the short-term interest rate under control by the central bank and “the interest rate” faced by private economic agents, a concept advanced by Woodford (2010). This relation is then incorporated into a set of equations based on a canonical New Keynesian model in order to account *simultaneously* for the dynamics of the unconventional monetary policy measures pursued, namely large-scale asset purchases and forward guidance over the policy interest rate. In addition, and for the sake of providing a theoretical-driven relation, the author discusses the role of the main monetary policy transmission mechanisms through which conventional and unconventional policies operate.

Following the literature review presented in Chapter 2, the need to broach a more “palpable” topic of research, namely an assessment on the effectiveness of unconventional monetary policy emerged; an empirical study on the behavior of financial variables throughout the short-term nominal interest rate zero-lower period could meet this purpose. This is how Chapter 3 appeared. Before 2008, the policy instrument used by the Fed was the federal funds rate, which implied that empirical studies on the evaluation of monetary policy could emphasize directly the links between asset prices and changes in short-term interest rates, likely with the assumption that in the window bracketing the monetary policy announcement, the news therein were the main driver of asset prices. However, with unconventional policies, there is no clear measure of the central bank’s policy stance. But even in this environment news still arise in a lumpy way; it is simply more difficult to measure. A vast literature emerged

over the last years to tackle this issue with a view to adapt the conventional event-study methodology, namely consisting of econometric regressions and vector auto regressions, to study the effects of monetary policy surprises in this new setup. Herein we extend Kiley's (2014) paper by treating monetary policy news as an unobserved process and by applying his analysis, confined to equity prices, to several variables.

A study, spanning the period 2008-2015 when the Fed Open Market Committee held regular meetings, is performed on the effects of the Fed's unconventional monetary policies over several financial variables, ranging from government bonds, corporate bonds, and exchange rates to stock returns. An unobservable variable approach, whenever possible, is used and evidence obtained suggests that these policies were generally effective in bringing down the associated yields. A different methodology grounded on a heteroskedasticity-based approach seemingly upholds these conclusions. Moreover, a VAR using daily data on several variables in levels reveals that innovations to 10-year US Treasuries yields have persistent effects on other variables that taper off slowly, thus suggesting that the flow of monetary policy matters.

In addition to most of the literature, a foray is attempted at trying to disentangle the effects between different types of unconventional monetary policy: large-scale asset purchases and other measures, including forward guidance. Use is made of multivariate analysis technics as well as through splitting the sample according to the classification of monetary policy news into the two types of policy. Results, robust to both methodologies, suggest that large-scale asset purchases are more effective at lowering yields, particularly at longer maturities, while other measures, which include forward guidance, not only lower both 10-years German Bunds and British Gilts yields, but also rotate the US yield curve pushing generally short-term rates down and long-term rates up.

Chapter 3 deals with the past. But what about the future? How to build a resilient monetary policy, without necessarily discarding the conventional policy, which, after all, performed well for many years? May central banks rely on other monetary policy tools, if a serious recession hits again, while interest rates remain low? In order to answer this question, we present Chapter 4. Yellen (2016) argued that monetary policy will continue to be determinant in supporting a steady and healthy economy. Furthermore, she expects that the new unconventional monetary policy tools will

probably remain useful in future economic slumps; however, she does not discard the use of additional tools and the cooperation with fiscal policy makers in a context of low nominal interest rates. Buitter (2014) and Gali (2014, 2017), among (very few) others, study such tools, namely the use of money-financed fiscal stimuli without resorting to higher taxes or an increase in government debt, neither in the present nor in the future.

This essay complements these studies and analyses the effects of fiscal stimuli financed through *seignorage*, particularly an increase in government spending, a tax rebate, and the issuance of “*bonus checks*” specifically designed for consumption purposes. Use is made of DSGE and DDGE (acronym for *dynamic determinist general equilibrium*) models. A comparison is made with conventional debt-financed stimuli. The results, under appropriate calibration of nominal rigidities and as long as the shocks are not anticipated, suggest that under the former policies, particularly with “*bonus checks*”, there are strong effects on real economic variables and on welfare, with relatively mild consequences on inflation while also leading to a reduction of the government net debt to output ratio.

A complementary experiment is conducted to capture a zero lower bound constraint, and the results suggest that an accommodative monetary policy rule under commitment may provide a possible adequate answer, without relying upon fiscal stimuli. Alternatively, when nominal interest rates can be pushed to negative terrain (this may likely require, *e.g.*, the end of paper currency) money-financed stimuli, namely if accompanied with the issuance of “*bonus checks*”, may lead to positive outcomes, provided that nominal rigidities exhibit high values, as should be expected under extreme conditions of economic duress.

The downside to these measures is that, among other possibilities, governments may feel tempted to use them when in economic terms they are no longer required. Under such hypothesis, the outcome will likely be confined to an undesirable spike in inflation. This can be replicated by simply lowering the nominal rigidities in the model. In addition, central banks have other measures worth exploring, including unconventional monetary policies, should a stark recession strike again and nominal interest rates remain low, a scenario advanced by several authors, such as Goodfriend (2016) and Summers (2016).

Finally, Chapter 5 provides a brief discussion on some of the more general results obtained. By way of conjecture, we address issues ranging from how setting up the policy rate when interest rates are no longer at the zero-lower bound, to the unwinding of unconventional monetary policy, to the restraints still faced by the financial system, particularly in some countries of the European Union, or to the subject of technological innovation and secular stagnation.

References

- [Buiter](#), Willem, 2014, “The Simple Analytics of Helicopter Money: Why it Works Always,” *Economics E-Journal*, pp. 1-53
- [Cardani](#), Roberta, Alessia Pacagini, and Stelios Bekiros, 2017, “The Effectiveness of Forward Guidance in an Estimated DSGE Model for the Euro Area: The Role of Expectations,” UCD Center for Economic Research, WP 17/01, pp. 1-28
- [Gali](#), Jordi, 2017, “The Effects of Money-Financed Fiscal Stimulus,” Revised, mimeo, pp. 1-40
- [Gali](#), Jordi, 2014, “The Effects of a Money-Financed Fiscal Stimulus,” SSRN, DP 10165, pp. 1-50
- [Gertler](#), Mark, and Peter Karadi, 2013, “QE1 vs. 2 vs. 3...: A Framework for Analyzing Large Scale Asset Purchases as a Monetary Policy Tool,” *International Journal of Central Banking*, 9, pp. 5-53
- [Goodfriend](#), Marvin, 2016, “The Case for Unencumbering Interest Rate Policy at the Zero Bound,” Paper Presented at a Symposium Sponsored by the FRB of Kansas, August 26th, pp. 1-38
- [Kiley](#), Michael, 2014, “The Response of Equity Prices to Movements in Long-Term Interest Rates Associated with Monetary Policy Statements: Before and After the Zero Lower Bound,” *Journal of Money, Credit and Banking*, 46 5, pp. 1057-71
- [Smith](#), Noah, 2016, “Ben Bernanke’s The Courage to Act: A Review Essay,” *International Finance*, 19 1, pp. 108-118
- [Summers](#), Lawrence, 2016, “Secular Stagnation and Monetary Policy,” *FRB of St. Louis Review*, Second Quarter 2016, pp. 93-110
- [Woodford](#), Michael, 2010, “Financial Intermediation and Macroeconomic Analysis,” *Journal of Economic Perspectives*, 24 4, pp. 21-49
- [Yellen](#), Janet, 2016, “The Federal Reserve’s Monetary Policy Toolkit: Past, Present, and Future,” Remarks delivered at a Symposium Sponsored by the FRB of Kansas, August 26, pp. 1-18

Chapter 2

A Simple Relation to Capture the Mechanisms of Unconventional Monetary Policy

Walking on ice: Monetary policy before and after 2007

A Simple Relation to Capture the Mechanisms of Unconventional Monetary Policy

Abstract

The conventional models of monetary policy were incapable of analyzing the actions undertaken by monetary policymakers in response to the 2007-9 financial crisis. The author puts forward an unpretentious relation between the short-term interest rate under control by the central bank and “the interest rate” faced by private economic agents. This relation is then incorporated into a set of equations based on a canonical New Keynesian model in order to account for the unconventional monetary policy measures pursued, such as large-scale asset purchases and forward guidance over the policy interest rate.

Keywords: central banks, financial crisis, forward guidance, large-scale asset purchases, monetary policy, unconventional monetary policy

JEL codes: E32, E40, E52

1 The Great Moderation

On the eve of the subprime crisis, macroeconomics was at peace and at ease with itself. A long history of internal feuding between competing paradigms seemed to have come to an end. A state of reconciliation was achieved, a “New Neoclassical Synthesis” (Goodfriend and King, 1997), or for that matter a more divulged “New Keynesian Synthesis” [see, for instance, Gali (2008) and Woodford (2003)], exemplified in macroeconomic consensual models. These models offered a framework for monetary policy which promised to maintain price stability and to ensure low cyclical output volatility. The prevalent confidence was well represented by Lucas (2003, p. 1) who opened his speech to the American Economic Association with the following statement:

“Macroeconomics was born as a distinct field in the 1940’s, as part of the intellectual response to the Great Depression. The term then referred to the body of knowledge and expertise that we hoped would prevent the recurrence of economic disaster. My thesis in this lecture is that macroeconomics in the original sense has succeeded: its central problem of depression prevention has been solved, for all practical purposes, and has in fact been solved for many decades”.

Short-run economics has accomplished its mission, Lucas suggested, thus, economists should shift their attention to more important supply-side issues of long-term development. In a similar fashion, Blanchard (2009) argued that the state of macro was “good” after many years of “enormous progress and substantial convergence”. At the time, these statements appeared to be corroborated by more than two decades of low inflation and modest output oscillations in most of the developed economies. This period was dubbed the Great Moderation (Bernanke, 2004) and was widely credited to the judicious policies of central bankers (some call it sheer luck) who abode by the guidelines set by the New Neoclassical and the New Keynesian Synthesis models.

2 The end of the happy state of affairs

The happy state of affairs came to an abrupt end when the financial crisis following the subprime bubble burst in the summer of 2007, pushed the world into its most severe slump since at least WW II. And, much more so than in most economic recessions, not only did financial developments produced the downturn, but once events were taking place it was in the financial sector that this episode particularly stood out. As Reinhart and Rogoff (2009) show financial-driven recessions exhibit more severe and prolonged aftershocks. The collapse of large financial institutions, the contagion domino-type effects, the decline in asset values and consequent destruction of paper wealth and collateral, the interruption of credit flows, the loss of credibility in firms and credit market instruments, and the fear of default by counterparties, were all extraordinary. Although policy makers responded swiftly and in retrospect, apparently with the right moves, mainstream macroeconomic policy framework was at odds with the unfolding of events. The forceful intervention by governments and central bankers opened up new ground both in scale and scope, and with hindsight, one might say that in most of the worst-affected economies, the emphasis of the recovery effect has been centered on monetary policy.

For economists the significance of these events has been a crisis of a different kind. The analytical models that have become the norm over the previous two to three decades are not only incapable of explaining these unusual significant events, but are even unfitted even to integrate most of the, by now, commonly acquired understanding.

As of 2007, standard macro-models did not include financial variables other than a short-term interest rate and eventually an indicator for quantity of “money”. No explanatory variables were incorporated to account for impacts from the financial arena on the real economy other than the interest rate’s role in intertemporal consumers’ choice. These models simply cannot explain why the failure of firms such as the Lehman Brothers or AIG, in September 2008, could have such an effect on the economy, or why it became relevant for governments in the US and elsewhere to prevent firms from falling. Nor do they incorporate the explanation of why unusual actions undertaken by central banks would have any effect, ranging from purchasing targeted securities such as commercial paper and residential mortgages, to establishing special lending facilities referred by Bernanke (2014) as credit easing, to implementing forward guidance (FG), which is the management of expectations with respect to the future path of the short-term interest rate.

Analogous questions arise from looking at central banks’ balance sheets. Why did they pursue massive unprecedented expansion of its asset holdings (see Figure 1), known in the economic parlor as large-scale-asset purchases (LSAP) or quantitative easing (QE)?

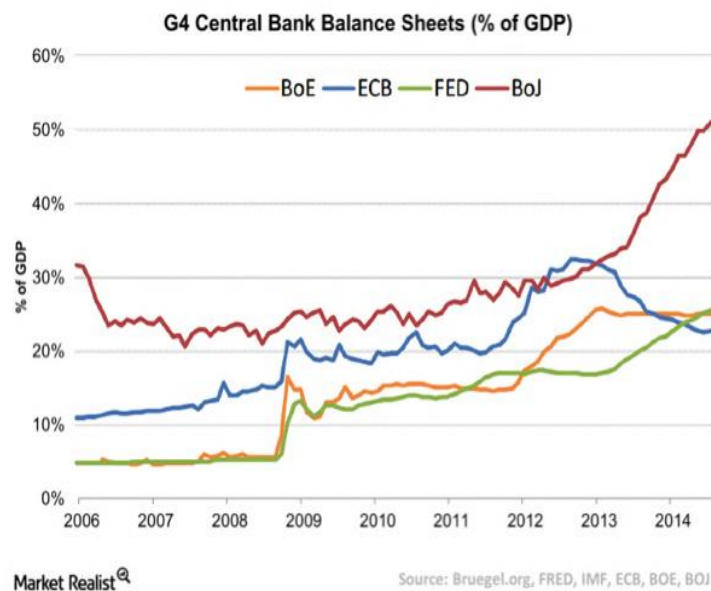


Figure 1: G4 Central Bank Balance Sheets ([color](#) figure available on line)

Why should an economist, using the conceptual framework of a state of the art conventional monetary policy model, (in retrospect, as mentioned, it did not include an active role for liquidity, financial markets and their imperfection) have expected these actions to affect the financial markets and, more importantly, real activity? On the other hand, looking at the liability side, essentially consisting of currency and excess reserves [a by-product of LSAPs (Craig and Koepke, 2015)], studies relating macroeconomics to “high-powered” money supply would have suggested not just an increase of a few percentage points in these economies rates of inflation but an enormous inflation. At least as of time of writing (last quarter 2017), such an increase has not taken place. Actually policymakers are concerned about the fears of deflation, although they will need to be increasingly alert to the risks once more sustainable economic recoveries begin to emerge (see Fischer, 2015). Policymakers must also pay significant attention to the financial stability risks associated with the long period of extremely accommodative monetary policy stance.

Goodhart (2010) notes that the standard approach in monetary economics to explain the supply of money, and the provision of bank credit, has been the money multiplier approach (see equation 1), whereby the central bank sets the high-powered monetary base (H), and then the stock of money (M) is a multiple of that. But when the monetary authorities in major developed countries attempted to use this relationship to expand the money stock and bank lending by force-feeding banks with base money, the prior relationship collapsed. As Table 1 highlights, despite huge increases in base money, measures of changes of broad money were mainly accounted by the former that is LSAPs, after materializing, represented the bulk of the Federal Reserve assets, were matched by increases in excess reserves

$$M = H * \frac{(1+\frac{C}{D})}{(\frac{R}{D}+\frac{C}{D})} \leftarrow \text{Money Multiplier} \quad (1)$$

M = Broad money supply, H = Monetary base, C/D = Currency/Deposits ratio, R/D = Bank reserves/Deposits ratio.

	M2	Reserves	Currency	Fed assets
2008-09-01	7811,9	43,1	834,2	1009,4
2015-09-01	12197,4	2649,4	1384,8	4484,7
Δ	4385,5	2606,3	550,6	3475,3

Table1 Tiny multiplier ($\Delta M/\Delta H=1.39$) Data relative to the US in \$billions. Source: Fred

Furthermore, according to the standard models, once the central bank's policy interest rate reached in practice the zero-lower-bound (ZLB), conventional monetary policy became simply useless. This financial crisis appears to have devastated the Great Moderation and discredited the New Neoclassical Synthesis. It would appear premature to relegate it to the heap of abandoned economic ideas (Woodford, 2012). After all, it has worked well for a long period of time during the Great Moderation. But the calm of that period might have induced economists into complacency which did not allow them to perceive how much they had limited their subject in terms of scope and methodology.

The experience of the crisis and the subsequent slump of the world economy suggest at least two general lessons for economists:

-First, the failure of the New Neoclassical Synthesis and the New Keynesian model to incorporate the mechanisms conducive to the financial crisis, namely the neglect of the financial sector and the complacency and risk-taking nurtured by the Great Moderation (de Groot, 2014).

-Second, the market system appears to follow different laws of motion in calm periods like in the Great Moderation and in time of crisis. This remark calls upon the consideration for markets non-linearity: small disturbances that push the economy not far away from its steady-state equilibrium may cause a more benign response, than large, once in a life "tsunami" (Mishkin, 2010, 2012).

The answer to these events deserves the credit of many economists who have reacted to the crisis with an abundance of research on the workings of financial intermediation and asset holdings, and particularly on the consequence of a variety of financial frictions and monetary policy transmission channels. Indeed, some research actually preceded the crisis, such as Bernanke and Gertler (1989), Holmstrom and Tirole (1997). Subsequent to the crisis, one may mention for example, Woodford (2010 and 2012), Gertler and Karadi (2011 and 2013), Curdia and Woodford (2011), Gilchrist

and Zakrajsek (2012). For a more comprehensive perspective, see Fischer (2015), Bernanke (2014), Mishkin and Eakins (2012), Williams (2012), and Smaghi (2009). Pervasive to all these papers is that no model (as far as we know), however simple, is advanced or referred in order to account for the “simultaneously” combined possible mechanisms of the two main monetary unconventional policy tools. Indeed, a thorough literature research revealed that models have been advanced explaining the dynamics of large-scale asset purchases, such as Gertler and Karadi’s (2013) seminal paper. The same applies to forward guidance. See for instance Harrison (2015) and Cardani *et al* (2017). However, no model is found encompassing both major unconventional monetary policies. There are studies on both policy tools, such as Woodford (2012) and Wright (2012), but they are either descriptive or empirical. This suggests that there is a lacuna to be filled.

More recently, Debortoli *et al* (2018), advance with the hypothesis of “perfect substitutability” between unconventional and conventional monetary policies. This suggests that a refreshment of the transmission mechanisms of the interest rate policy may be warranted, at least as an interlude.

The remainder of this article will delve in section 3 on the transmission mechanisms of conventional monetary policy setting the groundwork for the presentation in section 4 of a stylized model, literally a primer, enabling economists to grasp a conceptual framework within which one can address simultaneously how both main unconventional monetary policy tools (QE and FG) might work, using examples of measures undertaken by central bankers, which do not fit within any of the established models. A brief final comment concludes (section 5)

3 Monetary policy transmission mechanisms

The monetary transmission mechanisms describe how policy-induced changes in the nominal money stock or the short-term nominal interest rate affect real variables such as output and unemployment.

Central bank liabilities include essentially both components of the monetary base, that is, currency and bank reserves, commonly denominated “high-power money”. Therefore, the central bank controls the monetary base. In fact, monetary policy actions

basically start when the central bank changes the monetary base through an open market operation, buying securities (most frequently, government bonds) to increase the monetary base or selling securities to reduce the monetary base. Both currency and bank reserves are nominally denominated in terms of the economy's unit of account. Hence, if policy-induced changes in the monetary base are to have real impacts, nominal prices must exhibit some form of rigidity in a way that leaves the real value of the monetary base unaffected. Therefore, any theory of the monetary transmission mechanism must also assume that there exists some form of friction in the economy preventing nominal prices from adjusting immediately and proportionally to at least some changes in the monetary base.

If, as in the United States, neither component of the monetary base pays no interest (reserves started being remunerated in late 2008), or if, more generally, the components of the monetary base pay interest at a rate that is below the market rate, then private agents' demand for real base money M/P can be described as a decreasing function of the short-term nominal interest rate i : $M/P = L(i)$. This function L summarizes how, as the nominal interest rate rises, other highly liquid assets become more attractive as short-term stores of value. Hence, when the price level P cannot adjust fully in the short-run, the central bank's monopolist control over the nominal quantity of base money M also allows it to influence the short-term nominal interest rate.

There are, however, some caveats to this approach. Firstly, the measures of the money stock that the central bank can control tightly are not closely linked to aggregate demand. And the measures of the money stock that are often closely linked with aggregate demand, such as $M2$, are difficult for the central banks to control. Secondly, in many countries the relationship between all measures of money stock and aggregate demand has broken down in recent decades, weakening the case for money-stock rules (for a more recent review, see Timothy Lane, 2015). Because of these difficulties, central banks almost invariably conduct policy not by trying to achieve some target growth rate for the money stock, but by adjusting the short-term interest rate in response to various disturbances. In the background, of course, what allows them to pursue this is their control over the money supply.

3.1 The transmission channels

Mishkin (1995, 2007) interestingly describes the various channels through which monetary policy actions, as summarized by changes in either the nominal money stock or the short-term nominal interest rate, affect real variables.

According to the interest rate channel, a policy-induced increase in the short-term nominal interest rate leads first to an increase in longer-term nominal interest rates, as agents act to arbitrage away differences in risk-adjusted expected returns on debt instruments at various maturities, as described by the expectations hypothesis of the interest rates term structure. When nominal prices are slow to adjust, these movements in nominal interest rates translate into movements in real interest rates. Hence, aggregate output and employment change. This channel lies at the heart of the traditional Keynesian textbook IS-LM model, dating back many years (Hicks, 1937).

In open economies, additional real effects come through the exchange rate channel. When the domestic nominal interest rate rises above its foreign counterpart, equilibrium in the foreign exchange market determines that the domestic currency gradually depreciates at a rate that equates the risk-adjusted returns on various debt instruments denominated in each of the two currencies (the condition of uncovered interest parity). This expected future depreciation requires an initial appreciation of the domestic currency that, when prices are rigid, makes domestically produced goods more expensive than foreign produced goods. Net exports fall; domestic output and employment fall as well.

Additional asset price channels pertain to Tobin's (1969) q-theory of investment and Ando and Modigliani's (1963) life-cycle theory of consumption. Under these theories changes in short-term nominal interest rates impact on investment and consumption, hence on output and employment. Actually, some monetarists argue that monetary policy actions affect prices simultaneously across a wide variety of markets for financial assets and durable goods, but especially in the markets for equities and real estate.

Two distinct credit channels, the balance lending channel and the balance sheet channel, also allow the effects of monetary policy actions to propagate through the real economy. The former posits that during monetary contractions banks restrict some firms' loans, thus reducing their desired investment; financial market imperfections

confronting individual banks and firms, contribute in the aggregate, to the decline in output and employment (see Kashyap and Stein, 1993). The latter argues that a policy-induced increase in the short-term interest rate not only acts immediately through the interest rate channel depressing spending, it also acts, possibly with a lag, to raise each firm's cost of capital through the balance sheet channel, deepening the initial decline in output and employment (Bernanke and Gertler, 1995).

3.2 The New Keynesian model

This model seeks to understand how the traditional Keynesian interest rate operates within the context of a dynamic, stochastic, general equilibrium framework. It derives the key behavioral equations from basic descriptions of the objectives and constraints faced by optimizing households and firms.

More specifically, the basic New Keynesian model (see e.g., Romer, 2012) consists of three equations involving three variables: output y_t , inflation π_t , and the short-term nominal interest rate r_t . The first equation, which McCallum and Nelson (1997) dub the expectational IS curve, links output today to its expected value and to the ex-ante real interest rate computed by subtracting the expected rate of inflation from the nominal interest rate:

$$y_t = E_t y_{t+1} - \sigma(r_t - E_t \pi_{t+1}), \quad (2)$$

where σ , like all of the other parameters to be introduced below, is strictly positive. This equation corresponds to a log-linearized version of the Euler equation linking an optimizing household's intertemporal marginal rate of substitution to the inflation-adjusted return on bonds, that is, to the real interest rate. The second equation, the New Keynesian Phillips curve, takes the form

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t \quad (3)$$

and corresponds to a log-linearized version of the first order condition describing the optimal behavior of monopolistically competitive firms under any of a variety of conditions regarding imperfect price flexibility, as suggested, for instance, by Calvo (1983). According to Galí and Gertler (1999), this equation provides a good first approximation to the dynamics of inflation in the US.

The third and final equation is an interest rate rule for monetary policy, which can be derived from the optimization process of a quadratic loss function by the central bank, or simply represents a convenient rule of thumb such as the one proposed by Taylor (1992),

$$r_t = r^n + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - y^*) \quad (4)$$

where r_t is the short-term interest rate over which the central bank has control, π^* is the target rate for inflation, y^* is the target level of output and r^n is the equilibrium value of r_t for a given value of π^* . According to Romer (2012), Taylor argues that a rule like (4) with $\phi_\pi = 1.5$, $\phi_y = 0.5$, and $r^n = \pi^* = 2\%$ offers an adequate description of US monetary policy, particularly after 1985, when the Fed shifted its policy stance and up to 2007, one may surmise.

In this standard workhorse New Keynesian model, monetary policy operates through the traditional Keynesian interest rate channel. A monetary tightening that increases the short-term nominal interest rate translates into an increase in the real interest rate as well when nominal prices move sluggishly due to costly or staggered price setting. This rise impacts on output as summarized by the IS curve (eq. 2). Finally the decline in output, through the Phillips curve (eq. 3), puts downward pressure on inflation.

Importantly, however, the expectational terms embodied in the IS and Phillips curves imply that policy actions will differ in their quantitative aspects, depending on whether these actions are anticipated or not. Furthermore, by deriving these expectational forms from descriptions of the optimizing behavior of households and firms, the New Keynesian model takes advantage of the microeconomic foundations introduced into macroeconomics through Kydland and Prescott's (1982) real business cycle model.

Clarida, Gali, and Gertler (1999), Woodford (2003), and Gali (2008) delineate the New Keynesian model's policy implications in greater detail. Obstfeld and Rogoff (1995) develop an open-economy extension in which the exchange rate channel operates together with the interest-rate channel of monetary transmission, while Bernanke, Gertler, and Gilchrist (1999) develop the basic model in order to account for the balance sheet channel of monetary policy transmission.

4 A simple relation as the backbone of a model

However, in essence, there appears to be a chasm between the conventional monetary policy, herein referred to as the central bank's practice of setting the short-term interest rate to affect the market structure of interest rates, and thereby the cost of borrowing and the undertakings pursued by central bankers following the sub-prime burst in the summer of 2007.

4.1 Woodford's multiple interest rates

We will aim at presenting a simple relation and formulating a sketch that can function as a conceptual framework under which one can at least formulate questions. With this idea in mind, we will draw upon the contribution made by Michael Woodford in his paper "Financial Intermediation and Macroeconomic Analysis (2010)", as well as on asset market price literature, dating back many years ago.

In this paper Woodford analyzes why a new outline for economic analysis is necessary, as the standard macroeconomic models that do not embody financial intermediation and frictions consistent with institutional realities, namely at the peak of the economic downturn in 2007-09, are incapable of explaining the recent crisis. He underlines the role assumed by nonbank financial intermediaries, namely in the US, to explain the changes that occurred in terms of sources of credit particularly as a result of securitization, as well as the reduced contribution of bank deposits as the main source of funding for the financial sector. In the case of the US as of 2015 (1st quarter), only one third of the total credit was originated in the banking system and the remaining elsewhere (Fischer, 2015). In the Euro area, roughly the reverse takes place.

The article itself is based on Curdia and Woodford (2009) which presents a dynamic stochastic general equilibrium model on credit frictions and monetary policy. However, the model sketched here is an interesting extension of the Keynesian IS-LM model, or rather an IS-MP set-up which incorporates the existence of costly financial intermediation involving a wedge between the rate of return to primary savers, referred to as the "deposit interest rate", over which the central bank has control and the actual interest rate(s) faced by the borrowers, labeled for simplicity the "bank lending rate". These elements are then used to draft an explanation for the integration of financial

intermediation and credit frictions into macroeconomic analysis, leading to a model that can be used to analyze the macroeconomic consequences of the recent crisis, as well as implications for conducting monetary policy.

The extensions to the standard workhorse model, essentially based on a wedge between interest rates and impairments to the supply of intermediation, have a threefold impact upon the monetary policy actions. First, changes in credit spreads should be taken into consideration in the central bank's reaction function (Curdia and Woodford, 2009). Second, if the policy rate reached the ZLB, in the face of a sputtering (or declining output) economy and low inflation rates, the monetary policy function (eq. 4) calls for an unfeasible large negative interest rate (roughly four to five percent, if data pertaining to the U.S. as of the end of 2008 is plugged into the equation); under this scenario the central bank may extend credit to financial intermediaries on easier terms or engage directly in the purchase of securities, such as the purchase of commercial paper and mortgage-backed assets. Third, impairments to the supply of credit suggest adequate macro prudential measures aiming at financial stability. For details see Mishkin, 2012.

4.2 A relation between interest rates

We will consider again the New Keynesian model presented above, and reproduce it for ease of reference, with some minor changes in notation to capture the wedge in interest rates.

$$y_t = E_t y_{t+1} - \sigma(r_t^s - E_t \pi_{t+1}) + u_t, \sigma > 0 \quad (5)$$

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t + v_t, 0 < \beta < 1, \gamma > 0 \quad (6)$$

$$r_t^s = r^n + \phi_\pi(\pi_t - \pi^*) + \phi_y(y_t - y^*), r_t^s \geq 0, \phi_\pi > 0, \phi_y > 0 \quad (7)$$

Besides introducing disturbance terms in equations (5, and 6), an index is added to the short-term nominal interest rate, an idea borrowed from Woodford (2010). It now stands for savers' short-term interest rate controllable by the central bank as the policy interest rate.

As we have seen this model functioned reasonably well over the previous two to three decades preceding the crisis, but became unsuitable, particularly when the short-

term policy interest rate reached the zero lower bound. Following Woodford (2010), we believe it can be adapted in order to capture the policies undertaken by the central bank, not only asset purchases and credit intervention, but also forward guidance. Two subtle, but significant changes are to incorporate in the aggregate demand function, the interest rate (r_t^b) that borrowers face, and not the policy interest rate, as well as, a longer time horizon in the expected inflation correspondent to the maturity relevant to the borrower, that is:

$$y_t = E_t y_{t+1} - \sigma[r_t^b - E_t(\pi_{t+})] + u_t, \sigma > 0 \quad (8)$$

In order to incorporate these changes to the aggregate demand function, we must abandon the assumption that all non-money assets are perfect substitutes. That is, we have to face financial frictions preventing arbitrage. Woodford (2010) advances for example with financial costs implying that $r_t^b > r_t^s$, as well as limits to capital and leverage, either due to regulation on capital requirements or simply the intermediaries' creditors unwillingness to supply additional funding. Another perspective is to ponder collateral constraints in a context where the fraction of each asset's value that can be borrowed using that asset as collateral declines. A vast research on this subject has been developed over the last years, as previously referred. For an interesting description see the book by Holmstrom and Tirole, "Inside and Outside Liquidity" (2010).

Furthermore, relying on Finance theory, the securities issued by borrowers have typically longer maturities and are subject to potential default as opposed to central banks' short-term policy interest rates, which are essentially for risk-free liabilities, such as claims on banks' reserves held at the central banks; under these conditions (maturity and default risk) the obligations associated with the policy interest rate and the obligations issued by private borrowers are not perfect substitutes when investors are risk adverse. If, in addition, there is a serious financial crisis, then the difference between these rates increases significantly.

One may wonder why a section was dedicated to the description of transmission mechanisms of the conventional monetary policy as well as the transmission channels; these concepts were by then consensual (and still are). Well, once the federal funds rate reached the zero level in December 2008, the conventional monetary policy simply became non-operational and the Fed was constrained to the role of lender of last resort and a rescuer of collapsing financial markets. However, the rates actually available to

economic agents spiked up and the transmission channels conveyed to the economy the consequences of the financial shock. Literally, all the channels mentioned previously performed as expected, bringing down real variables and inflation. See equation 8, again. Hence, the implementation of radical different measures proved to be of essence, and became known as unconventional monetary policies. In retrospect, one might say that bringing down Woodford's r_t^b was now determinant, in a similar fashion as the traditional central bank's reaction function in the face of a more common milder recession.

In order to get a flavor for these statements, the picture below is fairly elucidative. It is clear that at the peak of the recession (shaded area) the federal funds rate spirals down towards zero, while other securities' spreads (r_t^b) jump up.

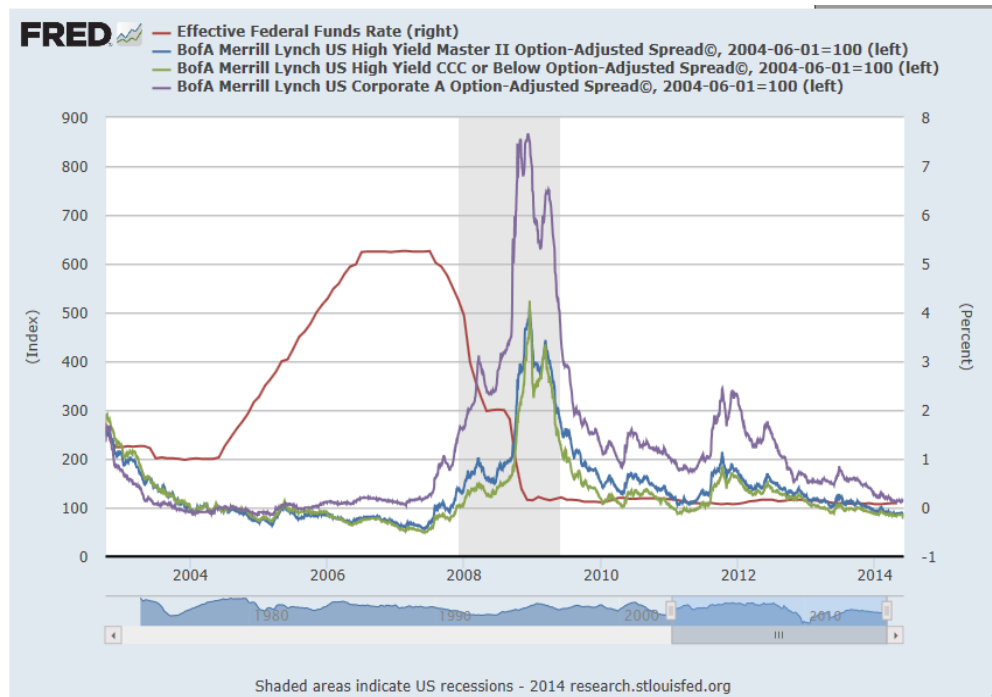


Figure 2: Some securities option-adjusted spreads and the federal funds rate (Source: Fred)

For the record note that an option-adjusted spread is a measurement of the spread of a fixed income security rate and the risk-free rate of return, which is adjusted to take into account an embedded option. Typically, the analyst would use the Treasuries securities yield for the risk-free rate. The spread is added to the fixed-income security price to make the risk-free bond price the same as the bond.

So, summing up ideas, we have a central bank determining r_t^s , according to equation (7); on the other hand we have private agents making investment or spending decisions according to (8). How can we relate these two rates: r_t^b and r_t^s , and simultaneously try to capture the actions undertaken by the Fed at least in regards to forward guidance and the early stages of LASP. We believe that a simple relation, the key element of this paper meets these objectives. Moreover, as far as we know, no relation has been advanced capturing at the same time the joint dynamics of the two main unconventional monetary policy tools.

$$r_t^b = \alpha r_t^s + (1-\alpha)E_t r_{t+}^s + f\left(\frac{R}{T}\right)_t + \varepsilon_t, 0 < \alpha \leq 1 \quad (9)$$

In this relation the first two terms on the right-hand side are set to replicate the yield curve, which is a weighted average of the short-term interest rates; specifically it attempts to reproduce the expected policy rate over a time frame corresponding to the maturity of the investment decision. For example, in the case that α is equal to unity, than the maturity of the investment corresponds to the duration of the policy interest rate. The proportion R/T is the ratio of risky assets to total assets required for the asset market to clear ($f_R > 0$), and ε is a disturbance term. The basis for the third term $f\left(\frac{R}{T}\right)_t$ in the equation is the standard asset-market equilibrium relationship. For the market to clear, the expected return on each asset must be such that the amount demanded by investors equals the amount of that asset in the market (the supply). If investors, or at least the marginal investor, are risk averse, the market-clearing expected return for each risky asset, relative to the return on the risk-free asset, depends on the fraction of the market portfolio that the risky asset comprises. If all assets are gross substitutes in investors' portfolios (a condition that in turn requires familiar regularity in the covariance structure of the respective risks of different assets) this relationship is positive: the greater is the share of the market portfolio consisting of any one risky asset, the greater will be the market-clearing expected return on that asset compared to the risk-free return. This is standard in the asset-pricing literature dating back many years and readily available in key reference manuals, such as Bodie *et al* (1996). For a more recent description, see Gagnon *et al* (2011) and the references therein. Indeed, evidence collected by these authors, shows, as expected that that assets subject to large

scale purchases are the ones that increase more in price, therefore, translating into subjacent lower interest rates.

This very simple model appears to provide us with an adequate interpretation of the mechanisms of unconventional monetary policy. The expression $E_t r_{t+}^S$ allows us to take into consideration the effects of central bank's forward guidance, which obviously is only effective if investors believe it. Research suggests that that it is the case, in particular when thresholds are associated with the central bank's communications (Femia *et al*, 2014). The expression $f(\frac{R}{r})_t$ allows embodying the effects of asset purchases; while buying private-sector securities, such as commercial paper and mortgage-backed assets, or through direct credit intervention, the central bank reduces the ratio of risky to risk-free assets that private investors hold, thus permitting a decline in the spreads, as was evident in the first quantitative program (see again Figures 1 and 2). The disturbance term ε_t permits us to account for exogenous shocks impacting on the private-sector interest rate r_t^b , such as financial disruptions, credit market collapses, losses of financial intermediaries, systemic deterioration of borrowers' net worth.

Combining equations (6), (7), (8), and (9) we obtain a very simple framework relating aggregate income to the borrowers' interest rate and the effects of monetary policy. For intuitive and simplicity sake, this can be represented in a two-dimensional graph.

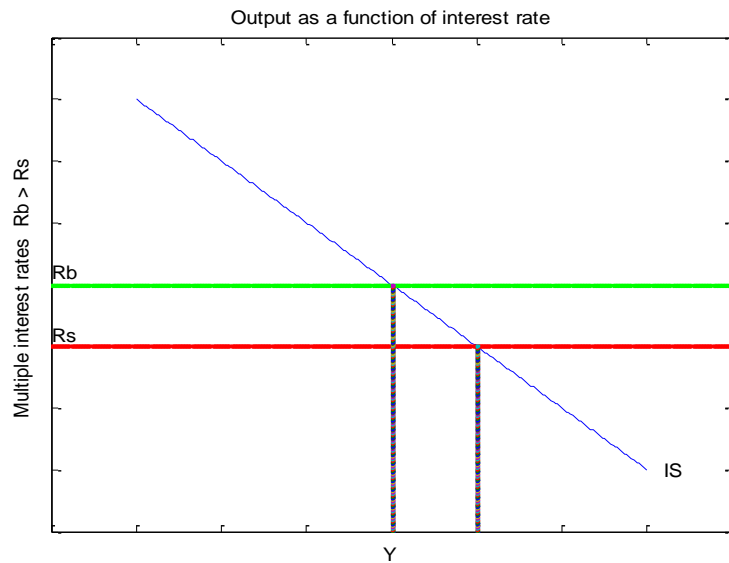


Figure 3: Output as a function of interest rate given other variables

Figure 3, contains a downward sloping IS curve, relating output y to the borrowers' interest rate, the relevant rate, for given values of the other variables. The horizontal line in red shows the level of the policy interest rate (r^s) set by the central bank (for the record, in the US, near zero percent between December 2008 and December 2015). The horizontal green line denotes the borrowers' interest rate, given the value of r^s and also for given values of the other variables. The main message to retain is that the output is obtained at the intersection of curve IS with r^b , rather than r^s , as advanced by Woodford (2010). While, not depicted in this figure, should there be a negative disturbance, it will raise the borrowers' interest rate and therefore reduce the output. In the case that the policy interest rate is positive, conventional monetary policy can be likely conducted to reduce or suppress the negative impact, by reducing r^s .

This last action was no longer possible, as mentioned, when central banks and policy makers were confronted with a ZLB, a severe economic downturn and a collapse in the financial markets.

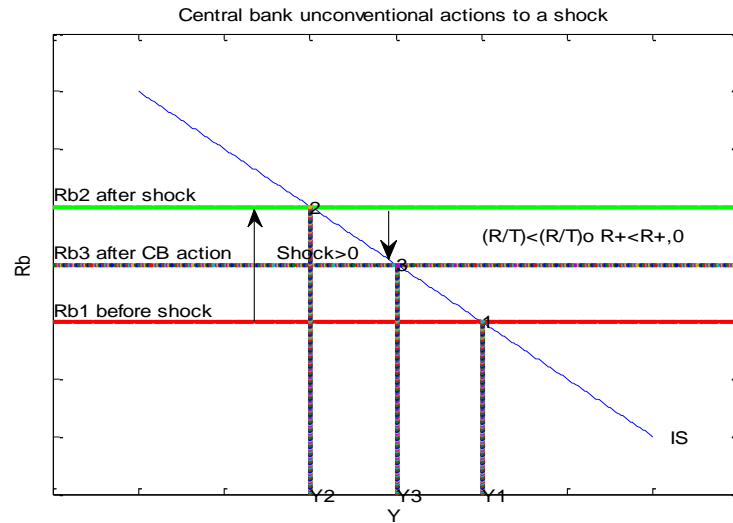


Figure 4: LSAP policy following a financial shock

Many central banks turned to purchases of private sector assets. In terms of equation (9), these actions translated into a reduction of R , the supply of potentially defaultable and longer-term assets that the market had to hold, without changing T , the total supply of securities; hence, we have a reduction in the ratio R/T and a tapering of

the spread between r^b , the borrowers' interest rate, and r^s , the “risk-free” policy interest rate, presumably near the zero level.

This is depicted in Figure 4. First, due to a shock, output falls from Y1 to Y2, following the increase in the borrowers' interest rate to r_2^b . Then, a purchase program is undertaken and output bounces back to an assumed higher level of output Y3 as the “relevant” interest rate drops to r_3^b .

This mechanism can be seen from the perspective of the dynamics of privately intermediated assets (S_t^p) as described by Gertler and Karadi (2011, 2013). In the event that these are insufficient to meet the demand for intermediate assets (S_t), assuming of course financial frictions and restrictions to the private intermediary financial sector, then, a central bank intervention (S_t^g) is likely warranted in order to fill in the gap and reduce spreads (or simply prevent possible credit rationing), that is:

$$S_t = S_t^p + S_t^g \quad (10)$$

Aside, asset purchases, central banks also undertook forward guidance. For example, following the December 12th, 2012, meeting the FOMC indicated it considered appropriate to abide by a ZLB rate “*at least as long as the unemployment rate remains above 6.5 percent, inflation between one and two years ahead is projected to be no more than a half percentage point above the Committee's 2-percent longer-run goal, and longer-term inflation expectations continue to be well anchored*” (FOMC, 2012).

Rather than overruling the monetary reaction policy function (7), one may interpret this public disclosure as a policy revealing that expectations' with respect to both output and inflation when compared to the desired levels remain low, and therefore the level of r^s in that function would continue to be in the zero lower area. The likely impact, provided that the disclosure is taken as credible, is that the term $E_t r_{t+}^s$ in (9) will remain low or fall. Should this be the case, we will have a downward pressure on the borrowers' interest rate. Graphically, this measure can be depicted as in Figure 4. A message to retain is that unconventional monetary policy tools at the ZLB aim at boosting a weak economy in recession by lowering financial costs, a goal shared by conventional monetary policy.

While such a graphic should suffice, one can obtain more revealing dynamics, though still sketchy, by drawing upon Jung *et al* (2005) who answer the question “What should a central bank do when faced with a weak aggregate demand function even after reducing the short-term interest rate to zero?” To address this question, they solve a central bank’s intertemporal loss minimization problem, in which the non-negativity constraint on nominal interest rates is explicitly considered. They argue that the best path for the nominal interest rate is defined by policy inertia, herein labeled Taylor rule under commitment (TRC), as opposed to a Taylor rule under discretion (TRD), in the sense that a zero interest rate policy should be continued for some time even after the natural rate of interest returns to a “normal” positive value.

For additional details with respect to the model, calibrations, and the definition of the exogenous negative shock, please see Chapter 4 (Sections 3.4 and 6). In practical terms, the solution to the problem is given by the minimization of

$$\sum_{t=0}^{\infty} \beta^t (\pi_t^2 + v y_t^2) \quad (10),$$

where v stands for the relative weight attributed to the output gap (y), subject to a sequence of constraints defined by the IS and the New Keynesian Philips curves

$$y_t = E_t y_{t+1} - \sigma(r_t^S - E_t \pi_{t+1}) + u_t, \sigma > 0 \quad (5)$$

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t + v_t, 0 < \beta < 1, \gamma > 0 \quad (6)$$

After running the model, one obtains the following graphs for the output gap and the short-term interest rate, under the control of the central bank.

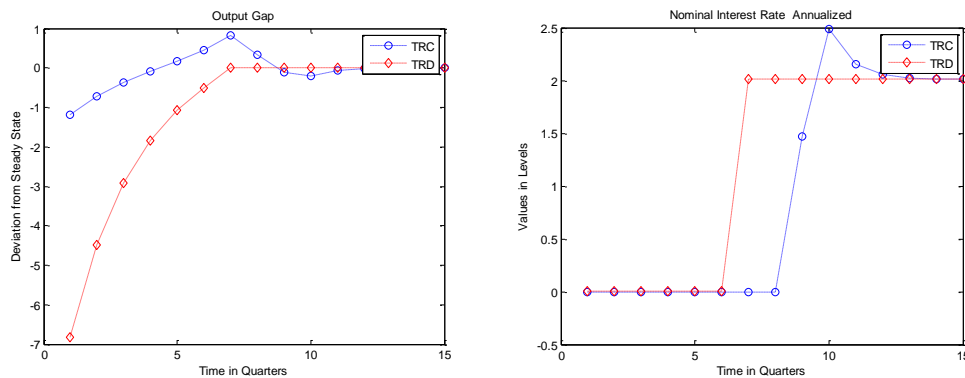


Figure 5: Forward guidance policy following a financial shock

Figure 5, clearly shows that a TRC policy under a liquidity trap, following a negative shock (- 1 percent of output) that materializes in period $t = 0$ and lasts for six periods, up to $t = 5$, may lead to a better outcome than a TRD policy, as well as, to nominal interest rates remaining low for a more prolonged period of time. Obviously, the success of such a policy is contingent upon agents believing on such a commitment.

5 Main conclusions

Monetary policy as implemented by most central banks in the advanced economies was subject to a severe disruption following the sub-prime crunch in the summer of 2007 and the ensuing financial crisis, which by all accounts was the starkest since World War II. Up to this time, monetary policy consisted essentially of fixing a short-term nominal interest rate. Once, in practice, these interest rates reached the zero lower bound, conventional monetary policy became useless. Central banks and policy makers were quick to undertake additional measures, such as direct credit interventions, targeted securities purchases and forward guidance on the short-term nominal interest rate aiming at avoiding the collapse of the financial markets and reducing private sector borrowers' interest rates and, thereby, propping up economic activity.

As in conventional monetary policy, unconventional policy operates by trying to reduce financial costs. Hence, there are similarities between the transmission mechanisms to the real economy. More recently, Debortoli *et al* (2018), advance with the hypothesis of “perfect substitutability” between unconventional and conventional monetary policies.

Additionally, there is no quantity theory of money associating the amount of base money to inflation provided of course that the economy is fragile and the banking system does not draw the excess reserves. Policymakers' decisions, and whatever economic developments ensued, have been a matter of the asset side of the central banks' balance sheets, not their liabilities.

Economists and researchers responded with vigor with the objective of understanding the workings of monetary policy operating under this different framework. The very simple relationship set forth here cautiously offers theoretical underpinnings and a synthetic model to explain simultaneously the mechanisms of

targeted asset purchases and forward guidance, which as far as we know, has not yet been put forward. Indeed, this relation calls upon the concept of actual interest rates faced by economic agents, which in turn depends on the present and expected short term interest rate (controllable by the central bank; the latter at least in terms of signaling) as well as on quantitative easing (also controllable by the central bank in terms of signaling and (or) in terms of actual targeted purchases).

References

- [Ando](#), Albert, and Franco Modigliani, 1963, “The Life Cycle Hypothesis of Saving: Aggregate Implications and Tests,” *American Economic Review*, 53 1, pp. 55-84
- [Bernanke](#), Ben, 2004, “The Great Moderation,” Remarks at the Meeting of the Eastern Economic Association, Washington DC, February 20
- [Bernanke](#), Ben, 2014, “The Federal Reserve: Looking Back, Looking Forward,” Remarks at the Annual Meeting of the American Economic Association, Philadelphia, January 3
- [Bernanke](#), Ben, and Mark Gertler, 1989, “Agency Costs, Net Worth and Business Fluctuations,” *American Economic Review*, 79 1, pp. 14-31
- [Bernanke](#), Ben, and Mark Gertler, 1995, “Inside the Black Box: The Credit Channel of Monetary Policy Transmission,” *Journal of Economic Perspectives*, 9, pp. 27-48
- [Bernanke](#), Ben, Gertler, Mark, and Simon Gilchrist, 1999, “The Financial Accelerator in a Quantitative Business Cycle Framework,” *Handbook of Macroeconomics*, Vol. 1, pp. 1342-1385
- [Blanchard](#), Olivier, 2009, “The State of Macro,” *Annual Review of Economics*, 1 1, pp. 209-228
- Bodie, Zvi, Alex Kane, and Alan Marcus, 1996, “Investments,” Irwin/McGraw Hill, pp. 997
- [Cardani](#), Roberta, Alessia Pacagini, and Stelios Bekiros, 2017, “The Effectiveness of Forward Guidance in an Estimated DSGE Model for the Euro Area: The Role of Expectations,” UCD Center for Economic Research, WP 17/01, pp. 1-28
- [Calvo](#), Guillermo, 1983, “Staggered Prices in a Utility-Maximizing Framework,” *Journal of Monetary Economics*, 12, pp. 383-398
- [Clarida](#), Richard, Gali, Jordi, and Mark Gertler, 1999, “The Science of Monetary Policy: A New Keynesian Perspective,” *Journal of Economic Literature*, 37, pp. 1661-1707
- [Craig](#), Ben, and Matthew Koepke, 2015, “Excess Reserves: Oceans of Cash,” FRB of Cleveland, Economic Commentary
- [Curdia](#), Vasco, and Michael Woodford, 2009, “Credit Spreads and Monetary Policy,” *Journal of Money, Credit and Banking*, 42 6, pp. 3-34
- [Debortoli](#), Davide, Jordi Galí, and Luca Gambetti, 2018, “On the Empirical (Ir)Relevance of the Zero Lower Bound Constraint,” Barcelona GSE WP 1013, pp. 1-25
- De [Groot](#), Olivier, 2014, “The Risk Channel of Monetary Policy,” FRB of Washington DC, Finance and Economic Discussions Series
- [Federal](#) Reserve, 2012, “FOMC statement on December, 12,”

- [Femia](#), Katherine, Steve Friedman, and Brian Sack, 2014, "The Effects of Policy Guidance on Perceptions of the Fed's Reaction Function," FRB of New York, SR 612, pp. 1-15
- [Fischer](#), Stanley, 2015, "Conducting Monetary Policy with a Large Balance Sheet," Remarks at the U.S. Monetary Policy Forum, New York, February 27
- Gali, Jordi, 2008, "Monetary Policy, Inflation, and the Business Cycle," Princeton University Press, pp. 203
- [Gali](#), Jordi, and Mark Gertler, 1999, "Inflation Dynamics: A Structural Econometric Analysis," Journal of Monetary Economics, 44, pp. 195-222
- [Gagnon](#), Joseph, Raskin, Matthew, Remache, Julie, and Brian Sack, 2011, "The Financial Market Effects of the Federal Reserve's Large-Scale Asset Purchases," International Journal of Central Banking, 7 1, pp. 1-43
- [Gertler](#), Mark, and Peter Karadi, 2011, "A Model of Unconventional Monetary Policy," Journal of Monetary Economics, 58, pp. 17-34
- [Gertler](#), Mark, and Peter Karadi, 2013, "QE1 vs. 2 vs. 3...: A Framework for Analyzing Large Scale Asset Purchases as a Monetary Policy Tool," International Journal of Central Banking, 9, pp. 5-53
- [Gilchrist](#), Simon, and Egon Zakrajsek, 2012, "Credit Spreads and Business Cycle Fluctuations," American Economic Review, 102 4, pp. 1692-1720
- [Goodfriend](#), Marvin, and Robert King, 1997, "The New Neoclassical Synthesis and the Role of Monetary Policy," NBER Macroeconomics Annual 1997, 93, pp. 231-296
- [Goodhart](#), Charles, 2010, "Money, Credit and Bank Behavior: Need for a New Approach," National Institute Economic Review, 214, F73
- [Harrison](#), George, 2015, "Estimating the Effects of Forward Guidance in Rational Expectations Model," European Economic Review, 79, pp. 196-213
- [Hicks](#), John, 1937, "Mr. Keynes and the Classics: A Suggested Interpretation," Econometrica, 5 2, pp. 147-159
- [Holmstrom](#), Bengt, and Jean Tirole, 1997, "Financial Intermediation, Loanable Funds, and the Real Sector," Quarterly Journal of Economics, 112 3, pp. 663-691
- [Jung](#), Taheun, Yuki Teranishi and Tsutomu Watanabe, 2015, "Optimal Monetary Policy at the Zero-Interest-Rate Bound," Journal of Money, Credit and Banking, 37-5, p. 813-835
- [Kashyap](#), Anil, and Jeremy Stein, 1993, "Monetary Policy and Bank Lending," NBER 4317, pp. 1-59
- [Kydland](#), Finn, and Edward Prescott, 1982, "Time to Build and Aggregate Fluctuations," Econometrica, 50 6, pp. 1345-137

- [Lane](#), Timothy, 2015, "Inflation Targeting: A Matter of Time," Speech delivered at the CFA Society, Halifax, Canada, October 25
- [Lucas](#), Robert, 2003, "Macroeconomic Priorities," *American Economic Review*, 93, pp. 1-14
- [McCallum](#), Bennett, and Edward Nelson, 1997, "An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis," NBER 55875, pp. 1-53
- [Mishkin](#), Frederic, 1995, "Symposium on the Monetary Transmission Mechanism," *Journal of Economic Perspectives*, 9, pp. 3-10
- Mishkin, Frederic, 2007, "Monetary Policy Strategy," MIT Press, pp. 539
- [Mishkin](#), Frederic, 2010, "Monetary Policy Strategy: Lessons from the Crisis," Prepared for the ECB Central Banking Conference, Frankfurt, November 18-19
- [Mishkin](#), Frederic, 2012, "Central Banking after the Crisis," Prepared for the 16th Annual Conference of the Central Bank of Chile, November 15 and 16
- Mishkin, Frederic, and Stanley Eakins, 2012, "Financial Markets and Institutions," Pearson Education Limited, pp. 709
- [Reinhart](#), Carmen, and Kenneth Rogoff, 2009, "The Aftermath of Financial Crises," *American Economic Review*, 99 2, pp. 446-472
- Romer, David, 2012, "Advanced Macroeconomics," McGraw-Hill, pp. 716
- [Smaghi](#), Lorenzo, 2009, "Conventional and Unconventional Monetary Policy," Lecture delivered at the IMCB, Geneve, April 28
- [Taylor](#), John, 1993, "Discretion versus Policy Rule in Practice," Carnegie-Hall Conference Series, 39, pp. 195-214
- [Tobin](#), James, 1969, "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, 1 1, pp. 15-29
- [Williams](#), John, 2012, "The Federal Reserve's Unconventional Monetary Policies," FRB of San Francisco, Economic Letter, 2012 34, pp. 2012-2034
- Woodford, Michael, 2003, "Interest and Prices: Foundations of a Theory of Monetary Policy," Princeton University Press, pp. 785
- [Woodford](#), Michael, 2010, "Financial Intermediation and Macroeconomic Analysis," *Journal of Economic Perspectives*, 24 4, pp. 21-49
- [Woodford](#), Michael, 2012, "Methods of Policy Accommodation at the Interest-Rate Lower Bound," Presentation at the Jackson Hole Symposium, Wyoming, August 31

Chapter 3

Assessing the Impact of Monetary Policy on Asset Prices Following the Zero-Lower Bound

Walking on ice: Monetary policy before and after 2007

Assessing the Impact of Monetary Policy on Asset Prices Following the Zero-Lower Bound

Abstract

This paper analyses empirically the pass-through effects of unconventional monetary policy conducted by the Federal Reserve (Fed) spanning the period 2008-15. Use is made of an unobservable monetary policy variable, whenever possible. The results, relying on daily data, suggest that these policies are effective at the zero lower bound in lowering yields and can be disentangled into its main components: in Fed speak, quantitative and non-quantitative easing. Moreover, the effects appear to be fairly persistent tapering off very slowly.

Keywords: central banks, financial crisis, forward guidance, large-scale asset purchases, unconventional monetary policy, zero-bound.

JEL codes: C20, E40, E43, E52

1 Introduction

During the recent financial crisis, the Federal Reserve (Fed) sharply lowered the target for the federal funds rate. In December 2008, the federal funds rate was set to the zero lower bound (ZLB), more specifically to a target range from zero to 25 basis points, where it remained up to December 2015. With monetary policy trapped at the ZLB, the Federal Open Market Committee (FOMC) started using other, less conventional, measures to further stimulate aggregate demand. This involved statements signaling that the funds rate would be kept at the zero bound for a long period of time, programs geared towards supporting some critical credit markets that became non-operational, namely at the early stages of the financial recession. It also included providing additional stimulus to the economy through large-scale asset purchases (LSAP) of Treasury securities and other high-grade bonds, a policy known in Fed speak as quantitative easing (QE). A fundamental motivation for these purchases was to try to lower the interest rates being paid by households and firms, so as to support consumption and investment spending. The justification, put forth by Fed officials,

relies, essentially, on a preferred habitat paradigm as described by Vayanos and Villa (2009) and, more recently, by Greenwood and Vayanos (2014), and also on the empirical work of Hamilton and Wu (2012), in which markets are segmented, investors demand securities of a specific type and the interest rate is determined by the demand and supply of that particular type of assets. LSAP could also operate in other ways, such as by impacting upon agents' expectations on the future path of monetary policy.

Before 2008, the policy instrument used by the Fed was the federal funds rate, which implied that empirical studies on the evaluation of monetary policy could emphasize directly the link between asset prices and changes in short-term interest rates as to verify the association with monetary policy measures (*e.g.*, Gurkaynak *et al* – 2005), likely with the assumption that in the window bracketing the announcement, the news therein were the main driver of asset prices. However, with unconventional policies, there is no clear measure of the central bank's policy standpoint, and no easy way to establish policy expectations. But even in this environment news still arise in a lumpy way; it is simply more difficult to measure. A vast literature emerged over the last years to tackle this issue with a view to adapt the conventional event-study methodology, namely consisting of econometric regressions and vector auto regressions (VAR), to study the effects of monetary policy surprises in this new setup. Table 1 lists some empirical studies, where we highlight the estimated decline in 10-year Treasury yield, expressed in basis points.

QE1: 12/5/2008 -3/31/2010	
(\$1,25 trillion mortgage backed securities purchases, \$300 billion Treasury security purchases, \$172 billion debt security purchases)	
Gagnon et al (2011)	91 (Event studies); 36 to 82 (Regressions)
Krishnamurthy and Vissing-Jorgensen (2011)	100
D'Amico and King (2013)	20 to 30 (Treasury security purchases)
D'Amico et al (2012)	35 (Treasury security purchases)
QE2: 11/12/2010 – 6/30/2011	
(\$600 billion Treasury security purchases)	
Krishnamurthy and Vissing-Jorgensen (2011)	25
D'Amico et al (2012)	55

Meaning and Zhu (2011)	21
Swanson (2011)	15
Maturity Extensions Program: 10/3/2011 – 12/30/2012 (\\$667 billion Treasury security purchases, \\$667 billion Treasury security sales/maturities)	
Hamilton and Wu (2012)	22
Meaning and Zhu (2012)	17
QE3: 9/14/2012 – 10/31/2014 (\\$823 billion purchases, \\$790 billion Treasury security purchases)	
Engen, Laubach, and Reifschneider (2015)	60

Table 1: Summary of some empirical studies (1st column) and the correspondent estimated declines in 10-Year Treasury yields in basis points (2nd column)

In the first round of studies, some authors have identified announcements that they claim to represent complete surprises, and then simply summed up the changes in asset prices taking place around statement days. This approach hinges on the entire announcement being unanticipated, as was arguably the case for some important news released by the Fed in 2008 and 2009. However, in fact, some announcements had already been, at least partially, expected and incorporated into the agents' reaction function. Other authors, such as Cahill *et al* (2014) relied upon survey expectations to measure the monetary policy surprises. However, surveys have limited data availability and are not necessarily perfect measures of investors' beliefs. For example, the announcement following the June 2013 FOMC meeting about the timeline for ending LSAPs was not far from survey expectations and yet agitated the fixed income markets.

Herein, we take a different approach, which is limited to measuring the relative effects of monetary policy on different asset prices. Following Kiley (2014), we model monetary policy surprises as an unobserved process, by first extending his analysis (confined to the association between equity prices and long-term interest rates) to other sets of assets, in a similar vein as Wright (2012) and Swanson (2016) propose. Kiley (2014) argues that simple regressions may be conducive to inaccurate inferences on the comovement of equity prices and interest rates subsequent to monetary policy actions. In particular he shows that an instrument variable (IV) approach offers accurate

inference. We define the monetary policy surprise, whose scale is unobservable, as the daily change in US Treasury yields around the day of announcement. The assumption that the scale of the action is not quantifiable seems reasonable, as it is difficult to consider a scalar able to incorporate the degree of surprise in forward guidance (FG), the other major unconventional monetary policy tool, or for that matter changes in the pace or course of LSAPs. There are two important considerations to be made about this strategy. First, it only measures the pass-through effects, from the monetary policy actions, onto other asset prices, not the effectiveness of monetary policy in affecting government bond yields. But this is still important, as some authors have questioned the ability of declines in government bond yields to be transmitted into other asset prices (*e.g.*, Eggerston and Woodford, 2003; Krishnamurthy and Vissing-Jorgenson, 2013). Second, it only measures the combined effects of monetary policy on asset prices, without decomposing it into the effects of specific policies, namely LSAPs and other measures, such as FG. It is not easy to separate the effects of different types of unconventional policy, as many announcements are literally hybrid as they covered simultaneously policies of different types. However, we also try to identify the effects of different types of unconventional policy news; moreover, we also broach the subject of persistency of news effects. An attempt, at separating the different types of unconventional monetary policies is advanced by Swanson (2016), but the methodologies that we use are different and include longer-term financial variables. The subject of persistency is dealt, among others, by Wright (2012) and Neely (2015), who arrive at different conclusions. The methodology that we employ, following Neely (2015) is based on a VAR and not a structural VAR (SVAR), as we find that is difficult, even spurious, to advance with dynamic specifications identifying relationships among the financial variables.

In this particular environment, the event study methodology is of far more interest than merely an academic perspective. Policymakers have seen the immediate effects of news announcements on markets and asset prices, and we dare to suggest that this has, in turn, helped to persuade them of the advantages of some unconventional monetary policies. A particular revealing example involves, for example, the European Central Bank (ECB) and the incumbent president, at the time of writing, Mario Draghi. Recall, for instance, his intervention at the Global Investment Conference in London on

July 26, 2012, stating that “*the [ECB](#) is ready to do whatever it takes to preserve the euro*”. This speech delivered at the height of the currency bloc’s sovereign debt woes, was followed by the containment of spiraling sovereign debt yields of perceived weaker peripheral countries of the Eurozone.

The plan for the remainder of this paper is the following. Section 2 describes the data, the methodology and proposes daily measures of monetary policy surprises. Use is made, whenever possible, of an instrumental variable(s) approach under the assumption that the relevant explanatory variable is not observable, as opposed to the usual event studies ranging normally from econometric regressions and VAR’s to SVAR’s. The results on the assessment of the impacts on several asset prices are presented and analyzed. Another methodology, which, as far as I know, has not been used before in the format presented (use is made of the US 10-year Treasuries), based on a volatility or heteroskedasticity approach and covering a larger data set (used to distinguish FOMC days observations from non- FOMC days) is then advanced and investigated. A foray is made (however without success) trying to detect different laws of motion in the early phases of unconventional monetary policies, when compared with later stages. Additionally, an experiment is performed comparing monetary “tightening vs. easing” outcomes during the ZLB period. Section 3 extends Swanson’s (2016) analysis by trying to discriminate and measure the effects of different types of unconventional monetary policy segregated into its two main components, calling upon two multivariate analysis techniques and judgmental grounds. In section 4 we delve into the subject of news persistency. Section 5 broaches policy implications. Section 6 presents the main conclusions.

2 Assessment of the effects following the announcements by the FOMC

2.1 Data and methodology

The period under analysis initiates in 2009, following the ZLB reached in late 2008, up to the end of 2015, coinciding with the raise of the federal funds rate to the 25-50 basis points bracket on December 16, 2015. Throughout this timeframe the FOMC held fifty six regular meetings. While, one might have considered other days, namely pertaining to important public interventions by central bank policymakers, we focus as Kiley (2014) on meetings’ observations. The objective is to study the financial market

effects of these specific announcements. While many of these announcements were either not very consequential (because, *e.g.*, were largely anticipated) others, on the other hand, came out as big surprises, which is of crucial interest for identification purposes. Figure 1, below, illustrates the change in the US Treasury yield curve on four selected occasions, deliberately chosen to underline stiff changes in US Treasury interest rates.

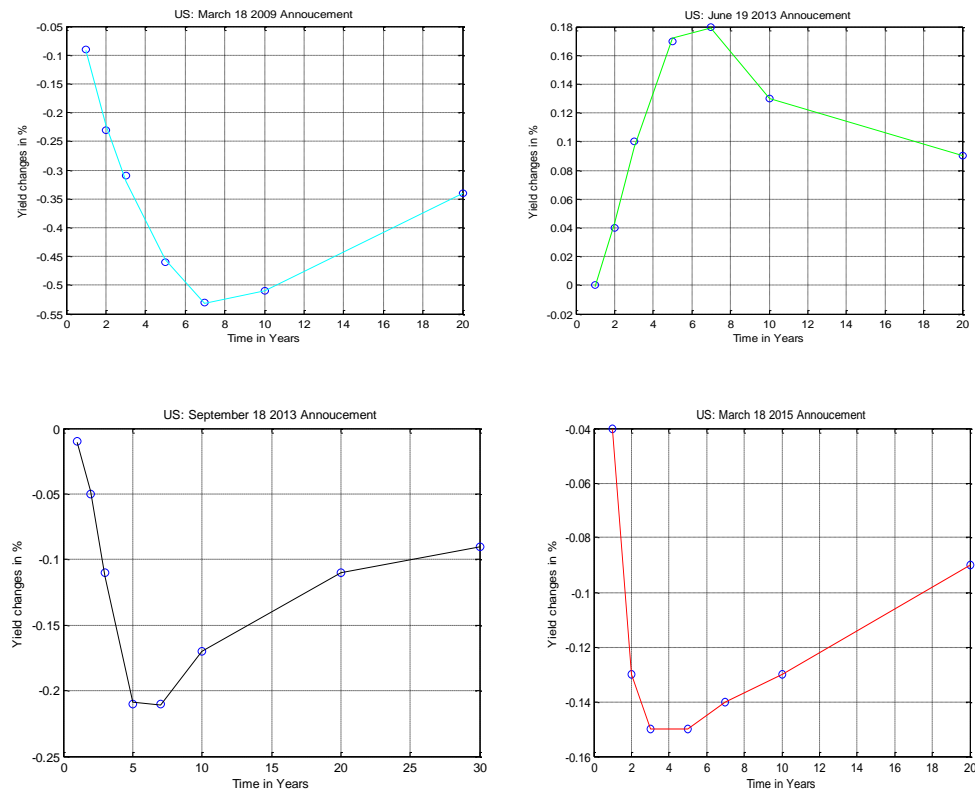


Figure 1: Changes in the Treasury yield curve on selected days (Source: US [Treasury](#) and author's own calculations)

As a positive surprise we have the Fed's announcement on March 18, 2009, of Treasury purchases. This led to the highest decrease in 10-year US Treasuries since Black Monday in 1987 (75 basis points), to the time of writing. Likewise, news on September 18, 2013, that the pace of the LSAP program would not change and on March 18, 2015, when it was decided to postpone a likely increase in the federal funds rate led to significant downward shifts in yields. As a reverse surprise, the Fed signaled on June 19, 2013, a possible earlier-than-expected end of LSAPs and investors brought forward the expected time of the beginning of monetary policy tightening, thus leading to an upward change in the Treasuries yield curve. Besides the fact that these

announcements produced significant changes at the five-year-ahead horizon and beyond (on June 19, 2013, it was somewhat more front-loaded), there are some reasons for thinking that some of these yield curve changes represent swings in term premium. First, surveys have shown no evidence of long-term expectations of futures rates moving much; in this regard see, for instance, the White House report on long-term interest rates (2015). Second, in these and other instances, it was the specific securities that the central bank bought or intended to buy whose prices changed the most, as argued, for example, by D’Amico *et al* (2012).

In this analysis, we use a number of asset yields, namely government securities, comprising, besides the federal funds rate, constant maturity US Treasuries (2, 5, 10, 10 inflation-adjusted, 20, and 30 years), British Gilts (10 years), and German Bunds (10 years), as well as US investment-grade corporate bonds (AAA, BBB), some exchange rates (dollar/euro, dollar/pound, and yen/dollar), a stock index (S&P 500), and the Chicago Board Options Exchange’s volatility index (VIX, also known as the “investor fear gauge”), which measures the level of a wide range of options based on the S&P 500. The data set was obtained from the Federal Reserve Bank of St. Louis (Fred), with the exception of the British Gilts and German Bunds, which were collected from Bloomberg. The yields on constant maturity government securities interpolated from the daily yield curve are based on the closing market bid yields on actively traded government securities in the over-the-counter market and are released daily, in the case of the US by the Fed. The corporate bonds indexes, reflecting the respective effective yields are made available on a daily basis by Bank of America Merrill Lynch. Many authors advocate the use of intraday or high-frequency data, such as Kiley (2014), and more recently Gertler and Karadi (2015), as it is potentially helpful to zero in on the window where monetary policy is theoretically the only information coming out.

However, announcements are sometimes complicated, and take time to be absorbed by agents. Therefore, the assumption that the monetary policy surprise can be directly measured from the swings in government bond yields in short windows around the news time is debatable. While a too narrow a window may miss part of the monetary policy announcements’ effects, a too wide window may lead to contamination of data by other than pure announcements factors. Bearing in mind this caveat, we will be using daily data.

In order to get a flavor for the data expressed in differences or differences of logarithms, we divide it into three groups for simplicity and homogeneity sake, which are consistent with the results obtained and shown ahead. The first group contains ten variables pertaining to government securities and corporate bonds (top-left panel). The second group consists of the three exchange rates (top-right panel), and the third includes the S&P 500 and the VIX indexes (bottom-left panel), as depicted in Figure 2 below. As it can be seen, the variables in the first group, while the graph is somehow crowded, appear to move in tandem and are cointegrated; moreover, they exhibit high positive correlation coefficients in particular among the US securities. In the second group the exchange rates are also cointegrated, but the correlation is somewhat smaller, while in the third group the “investor fear gauge” moves in counter cycle with the stock index displaying a high negative correlation and the variables are also cointegrated. Note for the record that, while not reported, to check for cointegration, use is made (and will be, henceforth) of the Johansen cointegration test.

In Figure 2 a histogram for the federal funds rate (in differences) is also shown; the median is zero and the average nearly zero, which is tantamount to discard this variable.

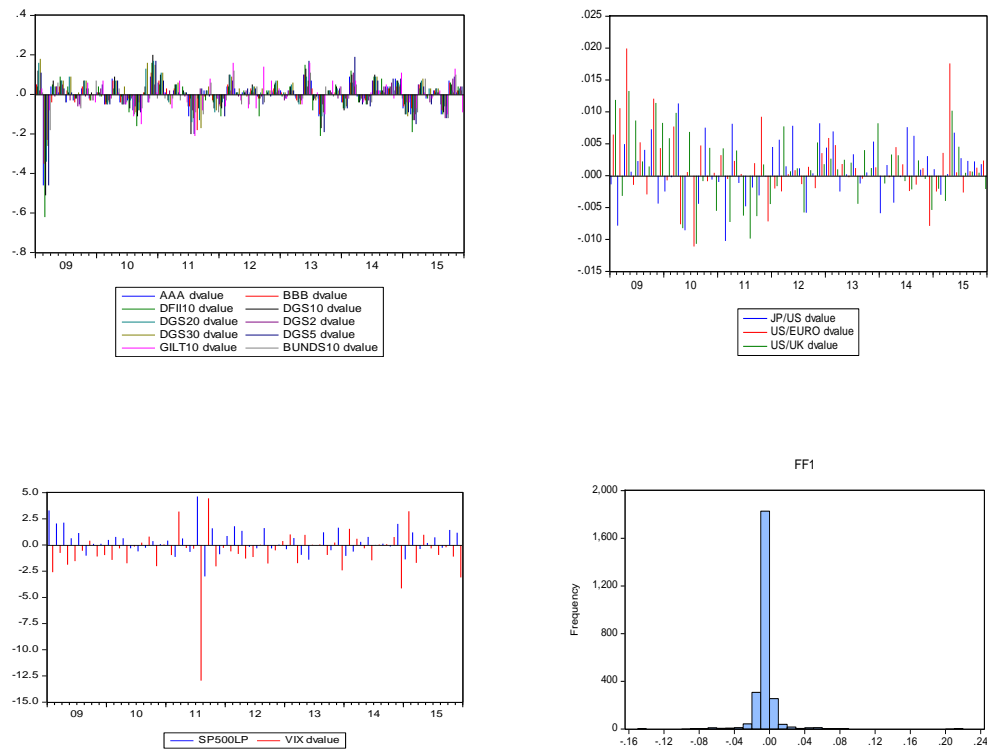


Figure 2: Surprises in interest rates, exchange rates, equity return and volatility index around FOMC meetings

We next discuss the identification strategy. The main assumption is that the scale of monetary policy actions is not observable; nonetheless it is taken for granted that policy actions are disclosed by FOMC releases or, for that matter, by relevant policymakers' statements (not considered at this stage). In fact, it is difficult to attribute a scalar to the degree of surprise to many of these announcements, though some authors have relied upon dummy variables (*e.g.*, Rosa, 2012). Prior to the ZLB, it was common to consider that the surprise in short-term interest rates was the observable surprise in monetary policy.

Let the unobservable monetary policy surprise be $\Delta X(t)$ and assume that this surprise affects the 10-year Treasury interest rate [$R(t)$ - this yield has received the most attention in the literature and as it is shown below an association can be traced with any other variable, even if indirectly] and equity prices $SP(t)$, with some independently distributed errors, as follows:

$$\Delta R(t) = \alpha \cdot \Delta X(t) + u(t) \quad (1)$$

$$\Delta \ln SP(t) = \beta \cdot \Delta X(t) + v(t) \quad (2)$$

The objective here is to determine the association between a change in the 10-year Treasury yield due to a shift in monetary policy and equity prices, which is the change in equity prices, caused by a variation of the monetary policy of size $1/\alpha$. The shift in equity prices is equal to β/α . However, as the scale is not quantifiable equations (1) and (2) cannot be solved; but, one can plug (1) and (2) and obtain:

$$\Delta \ln SP(t) = (\beta/\alpha) \Delta R(t) + w(t) \quad (3)$$

This equation should not be estimated by least squares, as the error term $w(t)$ is a combination of the other error terms; therefore the estimator β/α is bound to be biased and/or inconsistent. A conceivable solution calls upon the use of IVs with an instrument correlated with the change of $\Delta R(t)$, but uncorrelated with $w(t)$. As in Kiley (2014), we use yields on the 2-year and/or 5-year Treasuries as it seems reasonable that within daily observations, the joint movement with the 10-year Treasury yield is explained by monetary policy news; but in any event, the use of an instrumental variable methodology, be it two-stage least squares (2SLS) or generalized method of moments (GMM) among others, requires attention to the appropriate selection of instruments, the

satisfaction of orthogonality conditions, overidentifying restrictions and the endogeneity of the regressor (in this case, as indicated, the yield on the 10-year Treasury). We complement Kiley's analysis and methodology by extending it to other variables, some of which are not domestic, applying daily windows. The idea of measuring monetary policy surprises from asset prices was also carried out, among others, by Gurkaynak *et al.*, (2005) during the period of conventional monetary policy and Glick and Leduc (2012) using longer-term Treasury futures following the ZLB.

2.2 Impacts on financial variables

As Figure 1 suggests, the Fed was able, on the selected days, to produce immediate substantial effects on the US treasuries at different maturities, which most likely reveal modifications in term premia. This is corroborated by the results displayed in Table 2, where we are considering several variables. Column (1) contains least square estimates (LS), while columns 2 through 4 show the estimates using GMM, with 2 and 5-year treasuries [GMM (2&5)], 2-year Treasuries [GMM (2)] and 5-year Treasuries [GMM (5)] as IVs.

	LS	GMM(2&5)	GMM (2)	GMM (5)
AAA	0.58 (0.03) ***	0.72 (0.06) ***	0.82 (0.05) ***	0.77 (0.06) ***
BBB	0.65 (0.02) ***	0.60 (0.03) ***	0.65 (0.05) ***	0.62 (0.04) ***
BUND	0.38 (0.07) ***	0.37 (0.06) ***	0.42 (0.08) ***	0.38 (0.06) ***
GILT	0.65 (0.08) ***	0.43 (0.14) ***	0.47 (0.18) ***	0.44 (0.15) ***
DGS2	0.39 (0.04) ***	-	-	0.48 (0.05) ***
DGS5	0.91 (0.04) ***	-	1.08 (0.10) ***	-
DGS10	1.00	-	0.92 (0.09) ***	2.09 (0.23) ***
DGS20	0.74 (0.03) ***	0.71 (0.02) ***	0.67 (0.02) ***	0.71 (0.02) ***
DGS30	0.68 (0.04) ***	0.59 (0.03) ***	0.52 (0.04) ***	0.58 (0.03) ***
DFII10	1.00 (0.04) ***	1.01 (0.10) ***	0.92 (0.09) ***	1.04 (0.10) ***
JPUS	1.99 (0.59) ***	1.64 (0.38) ***	1.62 (0.39) ***	1.47 (0.40) ***
USEU	-1.06 (0.51) **	-0.21(0.52)	-1.67(0.39) ***	-0.66(0.50)
USUK	1.44 (0.78) **	0.80 (0.46) *	0.46 (0.49)	1.11 (0.49) **
SP500	-0.55 (1.49)	-3.37(1.83) *	-3.68(1.83) **	-3.37(1.82) *

Table 2: Response of financial variables to unconventional policies

Note: This table shows the estimates and standard errors (in brackets), for the impact of a 100 basis point shift in the 10-year US Treasury yield (DGS10). One, two and three asterisks indicate significance at the 10%, 5% and 1% significance levels, respectively. All variables, with the exception of the last four, represent variations in yields. The latter (three exchange rates and a stock index) are measured in percentage points, that is 100 times log price changes. Some IV estimates are highlighted in italic, meaning that besides being statistically significant, they meet the endogeneity, orthogonality, overidentifying restrictions where applicable and weak instruments tests. These statistics and p-values are not shown. All regressions are estimated without an intercept, as we are dealing with variables in

differences. DGS10 GMM regressions use alternatively DGS 2 and DGS5 (2 and 5-year Treasuries) as explanatory variables and IVs. Parameters in LS are estimated by robust regression.

Here we estimate LS regressions by robust regression to avoid excessive influence of outliers. In most cases, OLS estimations lead to similar results, but there are some coefficients where restricting the influence of outliers makes a considerable difference. In respect to GMM estimations, in particular when they satisfy the tests of endogeneity, orthogonality, overidentifying restrictions when the number of IVs exceeds the number of explanatory variables and weak instruments, the estimated parameters are generally lower, with respect to private and government bonds, than those estimated under LS. This is consistent with the hypothesis advanced that monetary policy surprises are not quantifiable and the error term $w(t)$ in equation (3) is correlated with the explanatory variable (10-year Treasury). There is one particular exception: high-grade corporate bonds (AAA) but, in this case, we detected a borderline endogeneity test, being accepted at the 10% significance level. Furthermore, when running an OLS regression the parameters do not differ that much. We were particularly concerned with the size of the sample (56 observations, though larger than Kiley's 32 observations), as GMM test statistics are only asymptotically valid. In any event care was taken in the selection of IVs in order to ensure a high correlation with the explanatory variable. Looking at Table 2, one can see that, generally, GMM regressions appear to be more suited, assuming the bias /inconsistency issue, than LS regressions, with the exception of German and British government bonds (BUND and GILT), as well as US investment-grade corporate bonds (BBB). Here, data suggests the use of LS.

From the table, one can infer that an easing of monetary policy significantly lowers corporate bond yields, but the drop in yields is less than one-for-one. This means that the yield spread of corporate bonds over their sovereign counterpart increases, though what should matter for the economic activity is the rate, not the spread. Yet, considering that LSAPs involve, namely, the purchase of government securities, it is important to be clear that the risk premium which is possibly falling is the term premium on government bonds, not the risk premium part of the corporate-government spread. One can also see that monetary policy news drop the US government bonds yield curve in particular at the 5 and 20-year horizon, and as expected (inflation

remained low throughout this time period) the fall in the 10- year constant maturity inflation-adjusted bond (DFII10) is nearly one-for-one.

Looking at the last row in Table 2, it can be seen that regardless of the IVs used, or for that matter of the choice of some of the weighting matrices, monetary policy easing based in this sample is associated with a raise in the stock price (SP500) in the vicinity of 3.5%. This is similar to the results obtained by Kiley (2014), though when using separately the 2 and 5-year Treasury securities this author arrives at lower values (1.7% and 2.2%, respectively) than the ones we obtained. Considering pre-ZLB data, Gurkaynak *et al* (2005) find that a 100 basis points surprise reduction in the federal funds rate was followed by a fall in the 10-year Treasury yields of some 40 basis points while equity prices rose by about 8%, thus revealing that the pre-ZLB and ZLB periods estimates are quite different. This suggests that conventional and unconventional policies are operating in different segments of the yield curve term structure. The former has large effects on short-term interest rates, while the latter impacts on long-term interest rates. Furthermore, as Kiley (2014) suggests, a given reduction in long-term interest rates (100-bp) triggered by monetary policy had a larger impact on equity prices (6-9% increase) in the era of conventional policy than during the unconventional policy period. Kiley (2014) argues that the attenuation in the ZLB period may not necessarily represent a change in the interrelations between equity prices and long-term Treasury yields but, instead, originates from the binding ZLB and the importance of both short and long-term interest rates in establishing the effects on equity prices of monetary policy news. Indeed, Kiley (2014) obtains significant parameters when estimating with IVs the association between changes in equity prices and changes in the federal funds rate and the 10-year Treasury in the pre-ZLP period (July 1991 through December 2008, with 157 observations).

The effects of monetary policy news by the Fed on exchange rates and German and British government bonds are also revealing, as they represent (presumably) unintended policy spill-overs. Indeed, the sample used displays that monetary policy easing is accompanied by significant shifts in the yields of bunds and gilts (38 and 65 basis points, respectively), while the dollar depreciates against the euro (1.65%) and the yen (1.6%), a trend found by Wright (2012). But, with respect to the pound, the data

shows the opposite: an appreciation of the dollar by a little over 1%, thus compounding the effect of the reduction of the 10-year gilt yield.

Deliberately, no results were presented pertaining to the volatility index (VIX). No significant associations could be found with the 10-year Treasury. In respect to this variable, we detected a highly significant inverse relation with equity prices regardless of the method applied. However, notwithstanding the association revealed by data between equity prices and the 10-year Treasury using IVs, no association could be established between the variable VIX and the latter. Interestingly, significant results and with the expected sign are obtained for these two variables (SP500 and VIX), as shown below, when using a principal component as an explanatory variable. Likewise, applying a technique (described below) called identification through heteroskedasticity yields significant results.

2.3 Alternative methodology: Identification through heteroskedasticity

In this section we extend the IV approach where the 10-year Treasury is the explanatory instrument to account for the impacts upon the other variables. Use is made of a technique developed by Rigobon (2003) that allows dealing with the two of the main problems in estimating the interactions between monetary policy and the variables of interest. One is the possible unobservability and endogeneity of variables, dealt in a similar way as in the subsection above through an IV approach; the other is the eventual existence of omitted variables, a more difficult task to undertake, requiring data mining and additional studies. Assume that the daily changes in the financial variables, considering two variables at a time (Δx_1 and Δx_2) can be characterized by a system of linear equations, whose reduced form is:

$$(\Delta x_1 \ \Delta x_2)' = D. (z_1 \ z_2 \ z_3 \ \dots)' + (\varepsilon_1 \ \varepsilon_2)', \text{ or in matrix form, (4)}$$

$$\Delta x' = D. Z' + E' \text{ (4a)}$$

where the matrix Z denotes the common factors affecting the financial variables, including the unobservable factor z_1 pertaining to the impact of monetary policies; the matrix E represents idiosyncratic shocks, while matrix D relates the direct impacts of

the common factors on the financial variables. The elements of this matrix are denoted d_{ij} and stand for the impact of the j th factor on the i th financial variable ($i = 1, 2$). The first column in matrix D represents the effect of the monetary policy factor on the two variables. The impact of this factor is normalized to unity to ensure that the scale of this factor is determined, and its impact on the second variable is captured by the coefficient d_{21} . This is the parameter to estimate for a set of variables.

If the common factors in matrix Z were all observable, then equation (4) could be estimated employing a LS regression. However, some of the common factors, including monetary policy are not observable. Rigobon (2003) proposes a heteroskedasticity-based methodology to estimate the impact of the monetary policy. This method only requires that a set of dates can be established on which the variance of the monetary policy factor is assumed higher than on other dates. This was already established when selecting the 56 FOMC meetings, which appears reasonable, even though the effects may precede the FOMC days (based for instance on expectations), or trickle out on the following days if, for example, the news are harder to “digest”. The identification rests upon the assumption that it is only the variance of monetary policy factor that changes on those days, while other factors notwithstanding being present exhibit the same volatility as on other days. Another assumption required is that the monetary policy factor be orthogonal to other shocks.

Consider now computing two variance-covariance matrices of the two financial variables as defined in equation (4). One matrix, denoted ψ_H is calculated using observations on FOMC days. The other matrix ψ_L is calculated using non-FOMC days (the indices H and L stand for high and low variance, respectively). Under the identification assumptions, the difference in the variance-covariance matrices between this two sets of observations $\Delta\psi = \psi_H - \psi_L$, is entirely explained by the change in the variance of the monetary policy factor, expressed as $\Delta\sigma^2(z_1)$. Specifically:

$$\Delta\psi = \Delta\sigma^2(z_1) \cdot \begin{bmatrix} 1 & d_{21} \\ d_{21} & d_{21}^2 \end{bmatrix} \quad (5)$$

As equation (5) reveals, the shift in the variance-covariance matrix between FOMC days and non-FOMC days is determined by the relative responsiveness of the financial variables to that factor. Consequently, one can compute the parameter of interest d_{21} , as indicated:

$$\hat{d} = \Delta\psi_{21} / \Delta\psi_{11} \quad (6) \text{ or } \hat{d} = \Delta\psi_{22} / \Delta\psi_{21} \quad (7)$$

These estimates would be asymptotically equal if the assumptions advanced held perfectly, namely that the factors other than monetary policy reveal the same heteroskedasticity over the two sets of periods (highly unlikely) and that the system of equations is linear. At this stage we can calculate these estimators; all that is required is to define a set of non-FOMC days. We chose the days before each Fed meeting, for a total of 56 observations (for that matter one can choose other set of days, such as for instance the days following the meetings), on the assumption that they will exhibit a different variance-covariance matrix. Indeed, they do, but we cannot establish their statistic value. In order to overcome this limitation, we rely upon Rigobon (2003), and Rigobon and Sack (2004) who show that these estimators can be implemented, applying an IV methodology.

These authors define as instrument a stacked variable consisting of the FOMC days' observations and the negative value of the observations pertaining to non-FOMC days, with respect to variable Δx_1 . Denote this instrument as ϕ_1 . A regression of Δx_{2C} is then estimated on Δx_{1C} , over both set of days (totaling 112 observations), using this instrument. The standard IV estimate is

$$\widehat{d}_1 = \text{inv.} (\phi_1' * \Delta x_{1C}) * (\phi_1' * \Delta x_{2C}), \quad (8)$$

which is equal to

$$\widehat{d}_1 = [Cov_H(\Delta x_1, \Delta x_2) - Cov_L(\Delta x_1, \Delta x_2)] / [Var_H(\Delta x_1) - Var_L(\Delta x_1)], \quad (9) \text{ or,}$$

$$\widehat{d}_1 = (\Delta x'_{1H} * \Delta x_{2H} - \Delta x'_{1L} * \Delta x_{2L}) / (\Delta x'_{1H} * \Delta x_{1H} - \Delta x'_{1L} * \Delta x_{1L}) \quad (10)$$

where the subscripts H, L and C denote respectively, the set of FOMC days, non-FOMC days and complete observations over the two sets of days. Note that the coefficient above is identical to the estimate in equation (6).

In a similar manner, one can consider an alternative instrument ϕ_2 defined in the same way but in terms of Δx_2 . With this instrument, the standard IV estimate is

$$\widehat{d}_2 = [Var_H(\Delta x_2) - Var_L(\Delta x_2)] / [Cov_H(\Delta x_1, \Delta x_2) - Cov_L(\Delta x_1, \Delta x_2)] \quad (11) \text{ or,}$$

$$\widehat{d}_2 = (\Delta x'_{2H} * \Delta x_{2H} - \Delta x'_{2L} * \Delta x_{2L}) / (\Delta x'_{1H} * \Delta x_{2H} - \Delta x'_{1L} * \Delta x_{2L}), \quad (12)$$

which is identical to the estimate in equation (7). Rigobon (2003) and Rigobon and Sack (2004) show that these two IVs are valid instruments for estimating \widehat{d}_1 and \widehat{d}_2 , under the assumptions that have been made. They further demonstrate that these estimates are consistent even if the shocks exhibit heteroskedasticity over time, as long as the volatility of the monetary policy shock accounts for the shift in the variance-covariance matrix on FOMC days.

We now turn to the application of these estimators using the 10-year US Treasury as Δx_1 and run an IV regression on this variable. The criterion to choose this variable is the same as the one presented in the sub-section above. The results are shown below.

	IV ϕ_1 (1)	IV ϕ_2 (2)	LS (3)
AAA	0.78 (0.06)***	0.78 (0.06)***	0.72 (0.04)***
BBB	0.62 (0.05)***	0.69 (0.06)***	0.63 (0.04)***
BUND	0.46 (0.10)***	0.40 (0.14)***	0.37 (0.06)***
GILT	0.56 (0.12)***	0.96 (0.19)***	0.42 (0.08)***
DGS2	0.49 (0.06)***	0.44 (0.07)***	0.41 (0.04)***
DGS5	0.98 (0.06)***	1.08 (0.06)***	0.92 (0.04)***
DGS10	0.93 (0.05)***	0.93 (0.05)***	0.97 (0.05)***
DGS20	0.66 (0.06)***	0.73 (0.07)***	0.77 (0.04)***
DGS30	0.52 (0.08)***	0.70 (0.11)***	0.66 (0.05)***
DFII10	1.10 (0.08)***	1.24 (0.09)***	0.99 (0.06)***
JPUS	1.94 (1.01)*	-5.16(5,26)	2.14 (0.56)***
USEU	-1.06(1.25)	8.65(13.07)	-1.06(0.51)**
USUK	1.61 (1.13)	2.43 (4.76)	1.57 (0.71)**
SP500	-6.27(2,73)**	-14.80(8.12)*	-1.35(1.67)
VIX	8.43 (4.58)*	43.60(25.81)*	1.72 (3.04)

Table 3: Responses of financial variables to unconventional policies applying volatility- based approach

Note: This table shows the estimates and standard errors (in brackets), for the impact of a 100 basis point shift in the 10-year US Treasury yield (DGS10). One, two and three asterisks indicate significance at the 10%, 5% and 1% significance levels, respectively. All variables, with the exception of the last four, represent variations in yields. The latter (three exchange rates and a stock index) are measured in percentage points, that is 100 times log prices changes. Columns 1 and 2 represent IV 2SLS regressions using as instruments, respectively, ϕ_1 and ϕ_2 , while in column 3 an OLS is applied. No intercepts are used, as the variables are expressed in differences. DGS10 estimates are calculated using DGS5.

In Table 3, we present the estimates, using the first IV (ϕ_1), the second IV (ϕ_2) and a LS regression for comparison purposes. Note that the volatility-based estimates converge to the traditional event-study estimation if the shift in the variance following monetary policy shocks is infinitely large. Under this hypothesis the changes in the variance from non-FOMC dates to FOMC dates converges to the variance on FOMC days, even though no such a strong assumption is required to arrive at consistent estimates. For the record note [compare with equation (9)] that the standard event-study estimate is given by:

$$\widehat{d}_3 = \text{inv.} (\Delta x_1' * \Delta x_1) * (\Delta x_1' * \Delta x_2) = \text{cov}(\Delta x_1, \Delta x_2) / \text{var}(\Delta x_1) \quad (13)$$

The two IV regressions, applying a 2SLS method lead to estimates, in some cases quite apart. Rigobon and Sack (2004), in their empirical paper use the equivalent to ϕ_1 as IV, allegedly for simplicity. However, when performing the weak instrument test (results not shown), one is steered to prefer ϕ_1 over ϕ_2 for this specific data set.

We now proceed to compare the estimates obtained employing ϕ_1 and displayed in Table 3 with the estimates shown in Table 2, above. With respect to investment-grade corporate bonds and government securities for a total of ten financial variables, notwithstanding the data sets being different, one arrives at the same conclusions and the estimated parameters are not actually that different. Moreover, computations made with GMM regressions and using a Newey-West weighting matrix (not shown), lead to identical estimates when using 2SLS, although with different statistics. This is explained by the fact that the IV equations are just-identified.

In regards to the exchange rates, the estimates though not statistically significant, exhibit the same sign and magnitude, as those shown on Table 2. Applying a plain-vanilla regression the estimated parameters are now statistically significant at least at the 5% level. Furthermore, they remain similar. The reverse happens with the equity and volatility indexes. The 2SLS regression (not the OLS) yields statistically significant estimates, which exhibit the expected signs and are larger in absolute value than those reported on Table 2. Table 4 provides some intuition for this volatility-based methodology.

	Variance ~FOMC	Variance FOMC	Covariance ~FOMC	Covariance FOMC	Estimates IV reg: ϕ_1	R-squared
AAA	16.71	62.31	17.23	74.66	0.78	0.78
BBB	16.44	48.31	18.90	64.53	0.62	0.80
BUND	21.81	33.56	4.13	37.19	0.46	0.16
GILT	14.65	54.35	3.10	43.39	0.56	0.14
DGS2	4.10	26.20	6.57	41.84	0.49	0.50
DGS5	20.78	97.41	23.31	94.90	0.98	0.87
DGS10	30.14	103.31	23.31	94.90	0.93	0.88
DGS20	32.89	68.08	30.47	79.33	0.66	0.86
DGS30	33.82	59.94	30.38	68.75	0.52	0.70
DFII10	20.53	120.23	21.34	101.87	1.10	0.77
JPUS	0.29	0.21	0.77	2.24	1.94	0.13
USEU	0.37	0.28	0.40	-0.35	-1.06	-0.05
USUK	0.29	0.30	0.45	1.66	1.61	0.05
SP500	0.93	1.48	3.24	-1.29	-6.27	-0.36
VIX	2,57	4.84	-4.45	1.60	8.43	-0.23

Table 4: Variances and covariances on FOMC and non-FOMC dates, IV and R² estimates

Note: This table uses daily changes in basis points (investment-grade and government bonds), daily percent changes in percentages points (exchange rates and the stock index) and daily changes (volatility index).

Table 4 reports some descriptive statistics on daily changes in the policy rate (DGS10) and other asset prices on FOMC dates and non-FOMC dates. With respect to investment-grade corporate bonds and government bonds there is a significant shift in terms of both variances and covariances with the policy rate. Using these values one can calculate directly the estimates of the IV regression (column 5 in Table 4) according to equation (9), which are identical to those reported in column 1 (Table 3), as expected. With respect to the exchange rates the difference in variances and covariances is not quite clear cut. For instance, the shift in variances is negative or hardly discernible. Furthermore, these three IV regressions fail to meet the endogeneity tests criteria; hence we calculate the associations relying upon LS, leading to similar, but significant, estimates. Note, as well that the statistic R-squared is particularly low for the dollar/pound and the dollar/euro exchange rates and high with respect to the US dollar

denominated assets. The reverse happens with the stock and volatility indexes. The change in variances, in relative terms, is patent, whereas there are changes of sign in the covariances from one set of dates to the other set. The test statistics in terms of significance, endogeneity and weak instruments suggest the use of the IV with ϕ_1 as an instrument. These estimates are higher in absolute value than those reported on Table 2 and exhibit the expected sign.

These results suggest, as in the previous subsection, that there is some, although modest, bias in the traditional event-study estimates, using LS regressions. Specifically, the volatility-based estimates reveal smaller impacts on bond yields; whereas the reverse happens with the two indexes, while the results for the exchange rates are not that different. Obviously, care should be taken, at least in terms of the selection of non-FOMC days. Some authors, such as Wright (2012) have implemented this approach using a SVAR over a much larger sample and then focusing on the reduced form residuals. An alternative, advanced by Rigobon and Sack (2004) is to use a set of non-FOMC dates larger than the FOMC dates. Anyway, the objective here is to provide a robustness test. Besides, the volatility or heteroskedasticity-based estimates, by requiring weaker assumptions than the traditional event-study estimate, may possibly deliver a more accurate measure between various financial variables and monetary policy.

2.4 Unconventional monetary policy at different stages

One may wonder if the effects of monetary policy news were dissimilar during the early phases of the ZLB and the following stages. Some authors, for example, the IMF Staff Report (2013) argue that LSAPs may have been more effective in the early phases when arbitrage capital was scarcer and markets were not operating normally. The question, then, is: are the spill-overs different according to the stages of unconventional monetary policy? In order to obtain an answer, an empirical method is used as well. The sample is split into two groups, one encompassing the observations spanning the period 2009 through 2011, the second including the remaining years. Regressions analogous to the ones used to obtain the estimators in Table 2 are applied, leading to the results shown on Table 5. No clear pattern emerges from this table with regards to the magnitude of the pass-through effects; however, the t-statistics tend to be

bigger in the first sample, possibly reflecting that it was in this period that greater monetary policy surprises took place. Similar results were obtained (not shown) when a clearer distinction between the recession period (2008-9) and the following years, representing the non-crisis sample, was applied. Note that, according to the National Bureau of Economic Research, the last recession started at the peak of the business cycle (2007 – IV Quarter) and ended at the trough (2009 – II Quarter). In short, this data does not differentiate the pass-through effects at the different stages, the exception being the stock index. However, when comparing the variances and covariances in the two periods, the values relative to the first period are systemically higher, as a mere visualization of Figure 2 clearly suggests. Hence, in spite of an important change in volatilities, it appears that the relative weights of the associated matrixes do not change that much. Hence, no conclusion can be obtained on the structural dynamics over the two periods.

	2009 - 2011	2012 - 2015
AAA	0.84 (0.06)*** 14.74	0.81 (0.09)*** 9.51
BBB	0.63 (0.06)*** 9.92	0.62 (0.04)*** 16.70
BUND	0.34 (0.05)*** 7.45	0.44 (0.12)*** 3.78
GILT	0.32 (0.09)*** 3.47	0.69 (0.15)*** 4.68
DGS2	0.40 (0.03)*** 7.87	0.63 (0.14)*** 4.58
DGS5	0.95 (0.05)*** 19.25	1.34 (0.10)*** 13.66
DGS10	1.06 (0.05)*** 19.25	0.75 (0.05)*** 13.66
DGS20	0.66 (0.03)*** 25.42	0.67 (0.03)*** 23.12
DGS30	0.49 (0.05)*** 9.40	0.60 (0.06)*** 9.76
DFII10	1.08 (0.14)*** 7.63	1.21 (0.05)*** 25.53
JPUS	1.96 (0.72)** 2.79	2.61(0.99)** 2.65
USEU	-1.92(0.41)*** -4.63	-1.19(0.59)** -2.05
USUK	1.29 (1.09)* 1.87	1.18 (0.96) 1.23
SP500	-5.26(2.61)** -2.17	-3.15(2.51) -1.25

Table 5: Comparison of effects on financial variables from unconventional monetary policies over two different periods: 2009-11 in column 1 and 2012-15 in column 2.

Note: This table shows the estimates, standard errors (in brackets) and t-statistics, for the impact of a 100 basis point shift in the 10-year US Treasury yield (DGS10). One, two and three asterisks indicate significance at the 10%, 5% and 1% significance levels, respectively. All variables, with the exception of the last four, represent variations in yields. The latter (three exchange rates and a stock index) are measured in percentage points, that is 100 times log

prices changes. Whenever possible regressions are estimated using an IV (highlighted in italics), meaning that besides being statistically significant, they meet the endogeneity, orthogonality, and weak instruments tests; otherwise they are estimated by LS. All regressions are estimated without an intercept. DGS10 GMM regressions use DGS5 and DGS2 (2 and 5-year Treasuries) as explanatory variable and IV, respectively.

2.5 Monetary easing *versus* monetary tightening

Here we attempt to analyze, using the 56 observations, whether there are differences in terms of effects of monetary policy news. This possibility has been explored in a conventional policy setting leading to inconclusive evidence (Kuttner, 2001) whether monetary policy easing effects contrast with monetary policy tightening in terms not only of sign but also level of impact. Throughout this period, it would appear that the Fed took predominantly an accommodative stance. Yet, this may be difficult to investigate, as within the framework of unconventional monetary policy many of the announcements led to monetary easing, but in other cases the opposite took place. See again Figure 1.

Nevertheless, in an attempt to separate and measure a possible difference, we generated two dummy variables. As a proxy for monetary easing we consider all scenarios where the 10-year Treasury yield change is negative, ending with 21 events. As a proxy for monetary tightening we consider the reverse occurrence, i.e. when the change in 10-year Treasury yield is either zero or positive. There are 35 events, under this criterion. This may seem surprising, but that is what this data set reveals. Recall that many decisions following the FOMC meetings did not reveal surprises and might actually have been anticipated. Then we consider the following equation:

$$\Delta Y(t) = \alpha D1(t) + \beta D2(t) + u(t) \quad (14)$$

Estimates of these parameters for several financial variables are shown in Table 6.

	D1	D2
AAA	-0.06 (0.01)***	0.03 (0.01) **
BBB	-0.06 (0.01)***	0.03 (0.01)***
BUND	-0.06 (0.01)***	0.01 (0.01)
GILT	-0.06 (0.01)***	0.03 (0.01) **
DGS2	-0.04 (0.01)***	0.01 (0.01) **
DGS5	-0.09 (0.02)***	0.04 (0.01)***
DGS10	-0.10 (0.02)***	0.05 (0.01)***
DGS20	-0.07 (0.01)***	0.05 (0.01)***
DGS30	-0.06 (0.01)***	0.05 (0.01)***
DFII10	-0.10 (0.02)***	0.04 (0.01)***
JPUS	-0.22 (0.08) **	0.30 (0.01)***
USEU	0.07 (0.12)	0.21 (0.09) **

USUK	-0.13 (0.11)	0.27 (0.09)***
SP500	0.12 (0.27)	0.52 (0.20)**
VIX	-0.31 (0.48)	-0.87 (0.38)**

Table 6: Monetary easing vs. tightening

Note: This table shows the estimates and the standard errors (in brackets) obtained by LS regression of a vector of financial variables, in differences, on two dummy variables D1 and D2. D1 takes the value of one when the change in the 10-year Treasury is negative and zero otherwise; the reverse happens with D2.

Looking at the investment-grade corporate bonds and government securities, with the exceptions of 10-year German bond in regards to D2 are all statistically significant and exhibit the expected sign. Furthermore the coefficients in D1 are systematically greater in absolute value than the coefficients in D2, whenever the regressions are statistically significant. The interpretation of the estimated coefficients is that impact from monetary easing actions is larger in magnitude than the negative impact of monetary tightening announcements, in conformity, we surmise, with the stance assumed by the Fed throughout this period. On the other hand, the more volatile variables, specifically the exchange rates (the exception being the yen/dollar), the equity and the stock-implied volatility indexes exhibit non-significant α estimators, though the β coefficients are significant at least at the 5% level. This means that the dollar appreciates against the yen, depreciates against the euro and the pound, the stock index price falls marginally, while the volatility index change is negative (this behavior does not appear to be consistent) on D2 days. The depreciation of the dollar against the yen on D1 days is smaller than the appreciation on D2 days. Note that, as the regressors are dummy variables, these estimates represent averages.

The common practice when running a regression on dummy variables is to assign the dummy variables in such a way that if a variable has m categories, one introduces $(m - 1)$ dummies. In this particular example two different specifications could be considered:

$$\Delta Y(t) = c1 + \eta D1(t) + u(t) \text{ or } \Delta Y(t) = c2 + \rho D2(t) + u(t) \quad (15)$$

The results obtained are the same as those under equation (14), but under a different garb. The advantage of these schemes is that they allow comparisons of results in terms of a reference category; however the main objective here is to compare the coefficients α and β , which are obtained directly from equation (14). Please note that it can be easily shown that: $\alpha = c2 = c1 + \eta$ and $\beta = c1 = c2 + \rho$. For instance, on D1 days (monetary easing) the yields on AAA bonds fall on average 6 basis points, whereas on

D2 days (monetary tightening) increase on average 3 basis points. Running the regressions specified in equation (15) with respect to AAA corporate bonds, the following outputs are obtained:

$\Delta \text{AAA} = 0.03 - 0.09.D1$ and $\Delta \text{AAA} = -0.06 + 0.09.D2$ ($\alpha = -0.06 = 0.03 - 0.09$ and $\beta = 0.03 = -0.06 + 0.09$)

3 Tentative disentanglement of unconventional monetary policy

In the previous section, we analyzed the effects of general unconventional monetary policy, without segregating it into its components, namely forward guidance, LSAPs, maturity extension programs, direct interventions to prevent particular markets from collapsing, namely at the early stages of the financial recession, and so forth. By now, it is broadly accepted that interventions in certain markets will translate into higher impacts upon the variables pertaining to the specific markets. As examples, consider, for instance, the commercial paper and the interbank money markets. In this section we will attempt at discriminating the effects of different types of monetary policy announcements. We will follow two different methodologies in order to try to accomplish decomposition.

3.1 A multivariate analysis approach

The first methodology that we rely upon in order to disentangle the effects of unconventional monetary policy is multivariate analysis. The main focus is to study the pass-through effects of monetary policy, assuming as an identifying strategy that the monetary policy is not observable, or at least, not quantifiable. Use was made of the 10-year Treasury yield changes and of 2 and /or 5-year Treasury yield changes to arrive at the results displayed on Table 2. As alternative IVs we have also used 20 and/or 30-year Treasury yield changes and the results obtained are generally consistent with those in Table 2 (results not shown). These results seem to indicate that these set of variables may assume a relevant role in the attempt to account for the impacts of an unobservable monetary policy variable on other variables, including themselves.

Indeed, these variables are co-integrated and display significant correlations, as shown in table 7.

	DGS30	DGS20	DGS10	DGS5	DGS2
DGS30	1.00				
DGS20	0.97	1.00			
DGS10	0.87	0.95	1.00		
DGS5	0.73	0.83	0.95	1.00	
DGS2	0.58	0.67	0.80	0.89	1.00

Table 7: Correlation matrix among US Treasuries yield changes

As an the identifying strategy, we propose now, based on the correlation matrix, the smallest number of unobservable common factors (i.e., the most parsimonious factor model) that best explain or account for the correlations or for that matter, covariations among the indicators. This is factor analysis, which yielded two latent factors, latent factor 1 and latent factor 2, accounting, respectively, for 78% and 22% of the total variance. One may find detailed explanations in reference manuals, such as Sharma (1996). According to Luciani (2009), factor models are a common tool for many sciences but did not achieve success in economics until more recently. Authors using this technique or derivations thereof include names such as Forni *et al* (2000) and Bernanke *et al* (2005). The factor loadings obtained show, as displayed in Table 8, that longer-term Treasury yield changes load mostly on the first latent factor, whereas shorter-term Treasury yield changes load relatively more on the second latent factor. Our interpretation is that the first latent factor represents LSAP, while the second latent factor represents other measures, which includes FG. This hypothesis rests upon the observation that LSAP focus on the purchase of longer-term securities, whereas other measures, such as FG, emphasize that shorter-term interest rates are expected to remain low, thus likely affecting mostly the near-side of the yield curve.

	Latent Factor 1	Latent Factor 2
DGS30	0.98	-0.03
DGS20	0.99	0.11
DGS10	0.91	0.39
DGS5	0.76	0.65
DGS2	0.60	0.66

Table 8: Treasuries yield changes unrotated loadings

In order to highlight this interpretation and obtain a better visualization an oblique ax rotation is shown in the Figure 3 below.

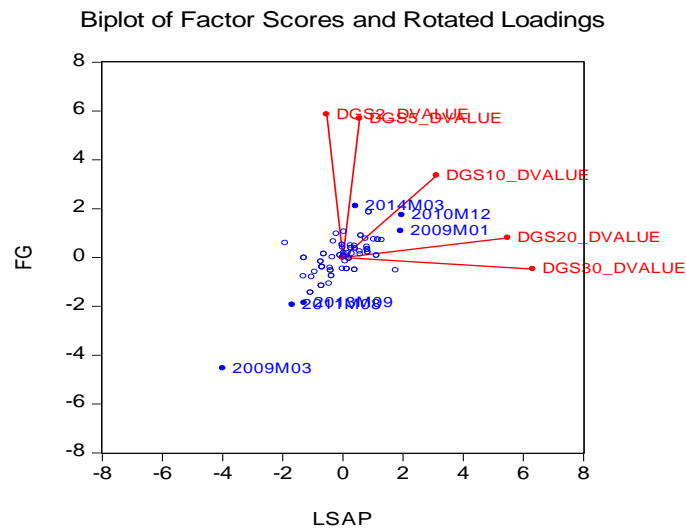


Figure 3: Factor Scores

For comparative purposes a factor analysis is performed over the same variables, but in levels and spanning daily observations over the period 2007 through 2015. Figure 4 suggests, notwithstanding, weaker test statistics, that a similar interpretation is applicable. A similar exercise covering data preceding the ZLB period was also performed by Swanson (2016) as a starting pad for the ensuing period where short-term interest rates hovered near zero.

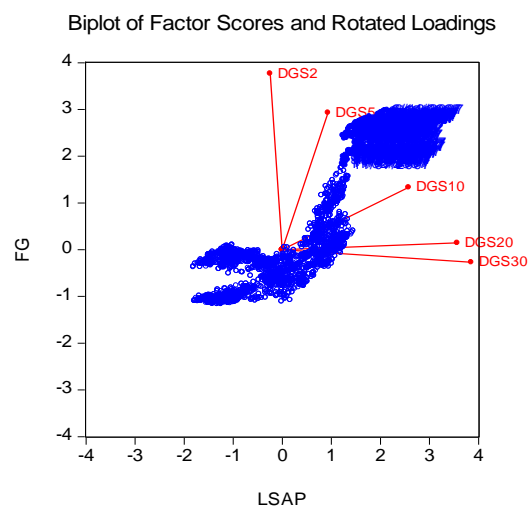


Figure 4: Factor scores on Treasuries daily data in levels

Having identified two factors that are responsible for the correlation among the US Treasury yield changes, we then proceed with the application of another multivariate technique that should uphold the interpretation suggested. Following Gurkaynak *et al* (2005) and Swanson (2016) we apply a principal component analysis (a different dimension-reduction process) to this data set consisting of Treasuries in order to detect those principal components. The orthonormal loadings are shown in Table 9.

	PC1	PC2
DGS30	0.43	-0.56
DGS20	0.46	-0.37
DGS10	0.48	-0.02
DGS5	0.46	0.34
DGS2	0.41	0.66

Table 9: Principal components scores

Similarly to factor analysis the eigenvectors loading into the first principal component (PC1) have roughly the same magnitude and may be viewed as an index, however the loadings in the second principal component (PC2) display a negative sign with respect to longer-term Treasuries yield changes and a positive sign for the shorter-term Treasuries yield changes. Note that these two principal components account for respectively some 86 and 11 percent of the total variance in the data set, which for practical purposes is more than adequate. Figure 4 is fairly elucidative.

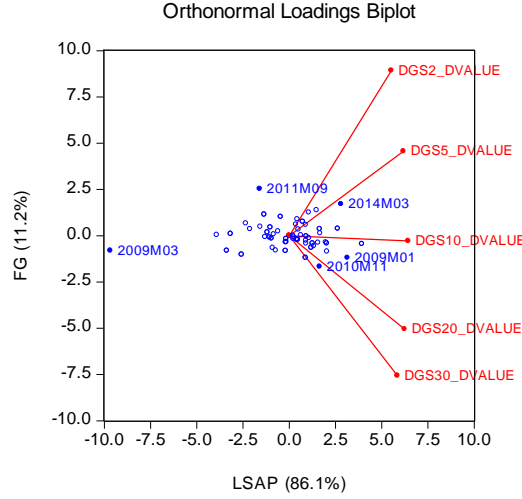


Figure 5: Principal Components' loadings biplot

Drawing from factor analysis, the interpretation is that PC1 characterizes LSAP measures, whereas PC2 represents other measures. The intuition behind this interpretation is actually quite simple. Surprise LSAP announcements, focusing on the purchase of longer-term securities, are anticipated to impact mostly on the far side of the yield curve, while it is unlikely that other measures, comprising FG news, are capable of affecting this segment of the yield curve.

Other authors, for other reasons, such as Bernanke and Kuttner (2005) used the first principal component of surprises in short-term interest rates to assess the impact on some financial variables in the conventional monetary policy era. In the ZLB period Wright (2012) uses the first principal component of 2, 5, 10 and 30-year bond futures. One must remember that principal components, by linking the information in a variety of interest rate measures, lower the influence of possible measurement errors. Additionally, in the presence of multicollinearity in the data, it leads to the formation of “new” variables, which are linear combinations of the original variables, such that the new variables are uncorrelated among themselves, thus permitting the development of a regression model. We consider the following specification:

$$\Delta Y(t) = \alpha PC1(t) + \beta PC2(t) + u(t) \quad (16)$$

where $\Delta Y(t)$ is the vector of yield changes and returns of the financial variables. The results are reported in Table 10.

	PC1	PC2	Single PC
AAA	0.35 (0.01)***	0.26 (0.04)***	
BBB	0.34 (0.01)***	0.11 (0.04)***	
BUND	0.23 (0.04)***	0.25 (0.13) **	
GILT	0.37 (0.05)***	0.23 (0.15)	0.27(0.05)***(PC1)
DGS2	0.27 (0.01)***	0.50 (0.03)***	
DGS5	0.57 (0.01)***	0.53 (0.04)***	
DGS10	0.55 (0.01)***	-0.08(0.03)***	
DGS20	0.42 (0.01)***	-0.42(0.01)***	
DGS30	0.36 (0.01)***	-0.62(0.02)***	
DFII10	0.53 (0.03)***	0.34 (0.08)***	
JPUS	1.05 (0.35) **	-2.00(1.10) *	
USEU	-0.58(0.32) *	-1.70(1.01) *	
USUK	0.77 (0.43) *	-3.40(1.37) **	
SP500	-1.18(0.89)	-11.01(2.83)***	-9.96(2.52)***(PC2)
VIX	1.60 (1.71)	15.22(5.41)***	14.13(3.10)***(PC2)

Table 10: Impacts of the first and second principal components on financial variables

Note: This table shows the estimated parameters estimated by robust least squares, in equation 16. The last column displays regressions onto only one the principal components, whenever one of the estimates was not statistically significant. 56 announcement days are considered. The two principal components account for 97% of the total variance.

The first principal component positive surprise (herein signed with a negative value) lowers all rates, in particular at maturities over two years, which appears to be consistent with LSAP easing measures. The second principal component positive surprise rotates the yield curve, pushing generally short rates down and long rates up, which can be construed as other measures. Looking at the exchange rates a positive PC1 leads to a depreciation of the dollar against the yen and the euro, and an appreciation versus the pound. A positive PC2 on the other hand depreciates the dollar against the euro and the pound, appreciates the dollar versus the yen, while leading to a statistically significant increase in the stock index return. A particular item draws the attention, which is the association between PC2 and the equity-related volatility index. An expansionary PC2 shock leads to a substantial reduction in the VIX index. This suggests that this type of policy (recall that PC2 includes FG and its main constituent is the 2-year Treasury yield changes) may reveal dynamics conducive to a reduction in uncertainty and an increase in the stock index return. Indeed, a close relation can also be found between the 2-year Treasury yield changes and the stock/volatility indexes.

There is a good deal of overlap in terminology and goals between principal components analysis and factor analysis. Much of the literature on the two methods does not distinguish between them, and some algorithms for fitting the factor analysis

model involve principal component analysis. In this regard, see, for instance, Sharma (1996). Both are dimension-reducing techniques, in the sense that they can be used to replace a larger set of observable variables with a smaller set of new variables. They also often give similar results. However, the two methods are different in their goals and in their underlying models. Roughly speaking, principal components analysis is appropriate to summarize or approximate data using fewer dimensions (to visualize it, for example), while factor analysis is suited to obtain an explanatory model for the correlations among a given data set. There appears to be some caveats to factor analysis, in this particular case. One has to do with the factor rotation indeterminacy, as described by Sharma (1996). Another stems from the fact that it is sensitive to the ordering of the variables. These two limitations led us not to present the results of the regressions of the various variables on the two latent factors. While several regressions revealed to be significant, the estimators differed substantially from those using principal components.

3.2 An attempt to classify monetary policy news

In this subsection we attempt to classify monetary policy announcements into two baskets. One contains news characterized by the prevalence of LSAP measures, while the second represents a mixture of policy actions; for lack of a better expression it is dubbed as non-LSAP or simply “others”, which includes FG measures, as well as other relevant unconventional policy. From reading the transcripts of the FOMC meetings, it becomes apparent that many of the announcements contain a mixture of policies, which may blur the classification proposed. Nevertheless, bearing in mind this caveat, Table 11 reports this separation of policy measures, which is similar to that of Gilchrist *et al* (2015). Additionally, a few more observations are considered, to be specific, eight more observations, one preceding the ZLB, other associated with some speeches by Ben Bernanke which triggered market turbulence. This option is twofold. Firstly, it increases the database in order to be able to arrive at more robust results; secondly, it adds volatility to the data, which is what one wants for identification purposes. The final outcome leads to 19 observations classified, mainly, as LSAP and 45 observations treated as non-LSAP measures. The intuition behind this segregation is actually quite simple and was presented in the subsection above.

	2008	2009	2010	2011	2012	2013	2014	2015
LSAP	<i>11/25</i> <i>12/01</i> <i>12/16</i>	1/28 3/18	<i>8/27</i> <i>9/21</i> <i>10/15</i>	<i>8/26</i>	6/20 9/13	<i>5/22</i> 6/19 7/31 9/18 10/30 12/18	6/18 7/30	
Other		4/29 6/24 8/12 9/23 11/4 12/16	1/27 3/16 4/28 6/23 8/10 11/3 12/14	1/26 3/15 4/27 6/22 8/9 9/21 11/02 12/13	1/25 3/13 4/25 8/01 8/31 10/24 12/12	1/30 3/20 5/1	1/29 3/19 4/30 9/17 10/29 12/17	1/28 3/18 4/29 6/17 7/29 9/17 10/28 12/16

Table 11: Dates of US monetary policy announcements.

Note: Non-FOMC announcements, consisting of Ben Bernanke's speeches and a FOMC meeting, are signaled in italics.

Then we estimate separately Equation (3) using LS and IVs regressions. The results are shown in Table 12.

	LSAP IV (1)	LSAP LS (2)	OTHER IV (3)	OTHER LS (4)
AAA	<i>0.80 (0.06)</i> ***	0.75 (0.04)***	<i>0.62 (0.06)</i> ***	0.57 (0.05)***
BBB	0.67 (0.01)***	0.67 (0.03)***	0.51 (0.06)***	0.59 (0.03)***
BUND	0.43 (0.06)***	0.39 (0.06)***	0.44 (0.13)***	0.44 (0.11)***
GILT	0.39 (0.15) **	0.42 (0.11)***	0.68 (0.14)***	0.61 (0.12)***
DGS2	<i>0.44 (0.12)</i> ***	0.43 (0.04)***	<i>0.60 (0.12)</i> ***	0.36 (0.07)***
DGS5	<i>0.91 (0.03)</i> ***	0.90 (0.04)***	<i>1.31 (0.11)</i> ***	0.89 (0.07)***
DGS10	<i>1.10 (0.03)</i> ***	1.07 (0.05)***	<i>0.77 (0.06)</i> ***	0.89 (0.07)***
DGS20	<i>0.72 (0.04)</i> ***	0.71 (0.03)***	<i>0.66 (0.05)</i> ***	0.83 (0.04)***
DGS30	<i>0.64 (0.08)</i> ***	0.61 (0.05)***	<i>0.53 (0.09)</i> ***	0.76 (0.06)***
DFII10	<i>1.18 (0.03)</i> ***	1.20 (0.06)***	<i>0.74 (0.15)</i> ***	0.77 (0.07)***
JPUS	2.94 (1.16) **	2.96 (0.85)***	1.78 (0.80) **	2.38 (0.89)***
USEU	<i>-1.39(0.70)</i> *	-0.93(0.69)N/S	<i>-1.44(0.78)</i> *	-0.34(0.87)
USUK	-0.76(1.36)	-0.42(0.83)N/S	-0.14(1.28)	2.57 (1.29) **
SP500	<i>-6.88(2.58)</i> **	-4.38(2.21) **	-2.97(4.86)	5.56 (1.99) **
VIX	<i>7.86 (3.07)</i> **	4.12 (3.57)	10.07(11.39)	-6.19(2.96) **

Table 12: Impacts on financial variables from disentangled unconventional monetary policy news

Note: This table shows the estimates (standard errors in brackets) for the impact of a 100 basis point shift in the 10-year US Treasury yield (DGS10). One, two and three asterisks indicate significance at the 10%, 5% and 1% significance levels, respectively. All variables, with the exception of the exchange rates and the equity index, represent variations in yields or differences. The latter (three exchange rates and a stock index) are measured in percentage points, that is 100 times log price changes. Some IV estimators are highlighted in *italic*, meaning that besides being statistically significant, they meet the endogeneity, orthogonality, overidentifying restrictions where applicable and weak instruments tests. These statistics and p- values are not shown. All regressions are estimated without an intercept. DGS10 GMM regression uses DGS5 as explanatory variable and DGS2 as IV. Parameters in LS are estimated by robust regression. The first two columns display estimators for the LSAP sample (19 observations), while the last two columns apply to the sample under “other” (45 observations).

The results reveal that LSAP easing impacts mostly (in terms of higher coefficients) upon the high-end of the US Treasury yield curve, at the investment-grade corporate bonds and the stock index, whereas other measures, which include FG, affect mostly the lower end of the Treasury yield curve and British gilts. The exchange rates, the exception being the US/UK, exhibit similar values with the expected sign. A surprise takes place with respect to the stock and volatility indexes under other measures; they reveal unexpected signs.

Some considerations should be made regarding the data. Firstly, we are using daily data; therefore highly volatile variables such as VIX and SP500L, as well as exchange rates may be tainted with other factors. Secondly the data set is different and its classification is based on judgement. Thirdly, there is the data size issue (19 observations classified as LSAP). This may raise robustness concerns, in particular when relying on IVs as the estimators are asymptotically valid. In this regard bootstrapping was applied to all the regressions in Table 12. The output (omitted) reveals that generally the resampled standard errors and associated t- statistics indicate that the relationships between the variables appear to be not accidental, whenever the original regressions were statistically significant.

More importantly though, considering the various exercises performed thus far, is that the type of data used appears to be determinant whether one should use intraday or daily observations. Variables such as foreign exchange rates, stock and volatility indexes are subject to very active trade on exchanges; thus the intraday option, which was not available, may likely be the appropriate choice. The tally of this limitation appears to be that generally one could not obtain “adequate” estimators. On the other hand, bonds and Treasuries, though liquid, trade on over the counter markets and are not subject to high volatilities. This may explain why more “adequate” estimators were derived for these instruments.

4 Monetary policy persistency

The methods employed in the preceding two sections aim at measuring the immediate effects of monetary policy news on a set of financial variables. This begs the question of assessing how persistent these impacts are. A common conjecture in the event study literature is that effects are long-lasting. However some authors argue (*e.g.*, the IMF Staff Report, 2013) that the evidence suggests that bond purchases were particularly effective in the US in reducing yields in the early LSAP stages. In fact, many of the important monetary policy shocks occurred at a time when markets were weakened, and subsequently effects of asset purchases may have been particularly expressive. Furthermore, LSAP and maturity extension measures might have induced additional issuance of long-term securities (Stein, 2012), which would tend to push up long-term rates, thus reducing the stimulus effect.

In order to try to answer empirically how persistent are the monetary policy effects, we draw upon a dataset consisting of daily observations of “well behaved” instruments negotiated over the counter, particularly, US investment-grade corporate bonds and constant maturity Treasuries (2, 5, 10, 10 inflation indexed, 20, and 30-year), straddling the period 2008 through 2015. A pictorial view of this data in levels is elucidative (see Figure 6).

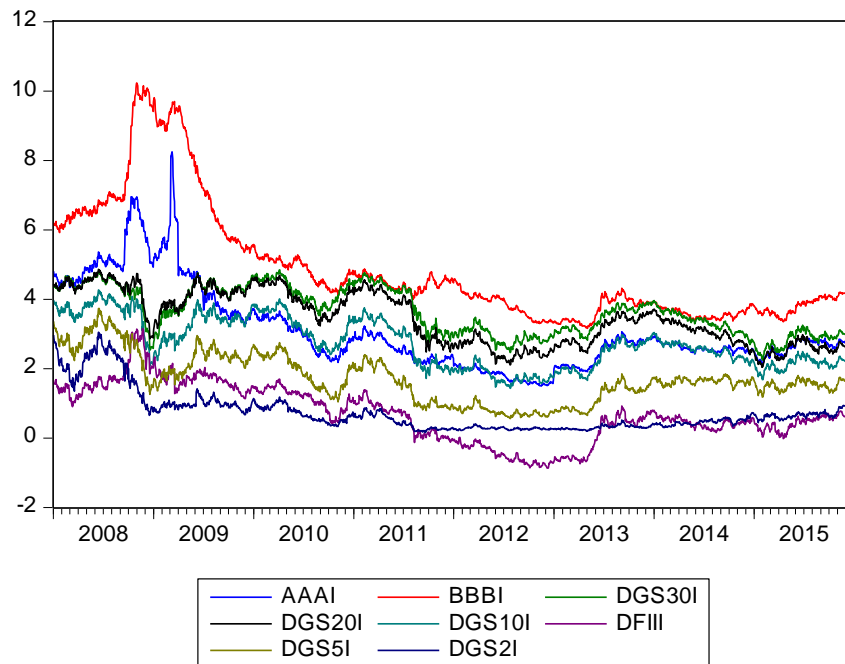


Figure 6: Interest rates of some US securities (the suffix I indicates variable in levels)

Figure 6 suggests that these variables move in similar wavelengths, with the exception of 2008-09, where there is a run for safer assets and corporate bonds yields spike up. However, throughout the period under analysis they are cointegrated. Hence, relations can be calculated between these variables in levels and the 10-year Treasury as shown in the Table 13.

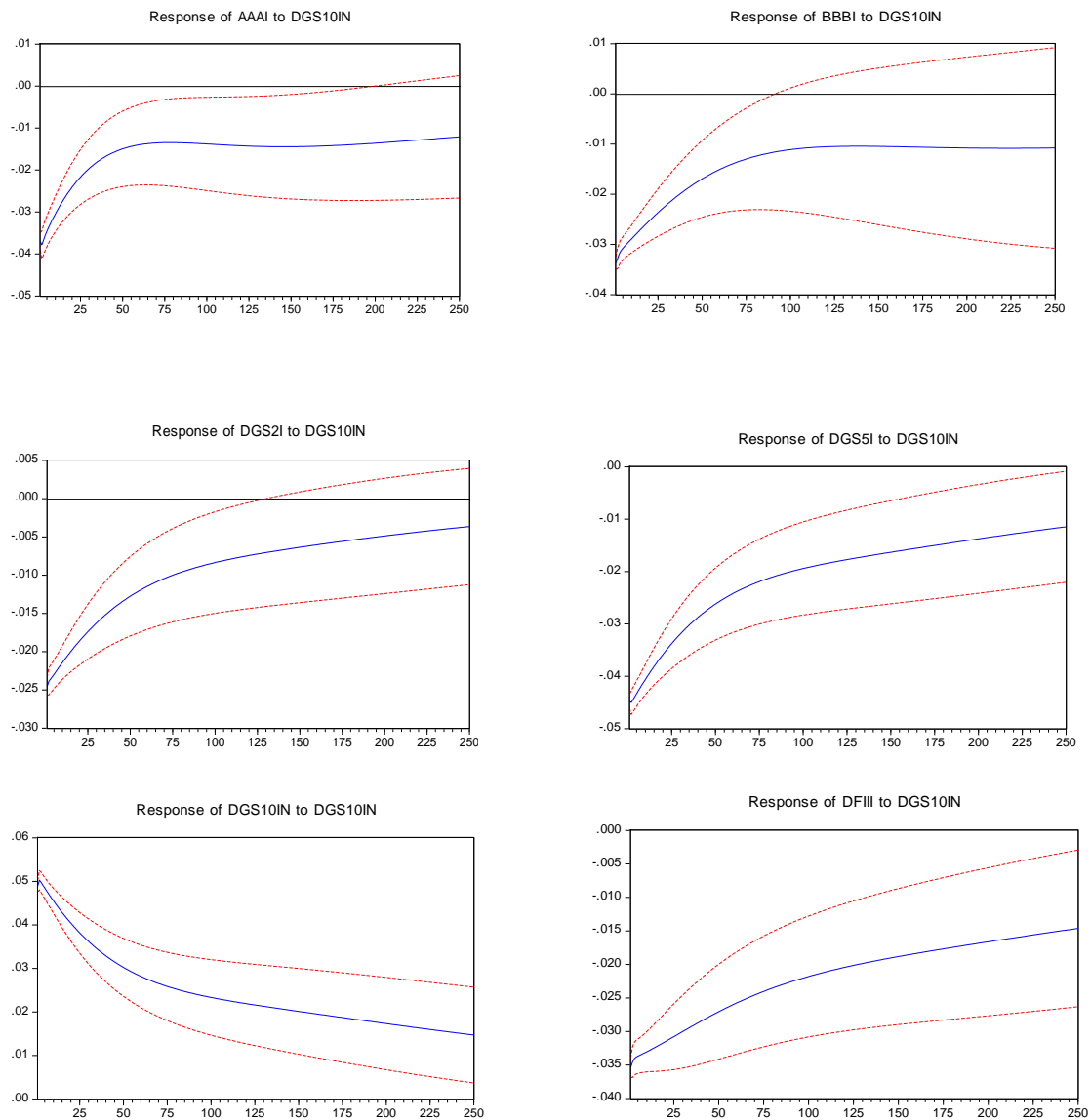
	IV	LS
AAA	0.75 (0.04)***	0.76 (0.02)***
BBB	0.73 (0.03)***	0.70 (0.01)***
DGS2	0.65 (0.05)***	0.50 (0.01)***
DGS5	1.16 (0.07)***	0.92 (0.01)***
DGS10	0.84 (0.05)***	0.93 (0.01)***
DFII10	0.81 (0.04)***	0.73 (0.01)***
DGS20	0.86 (0.02)***	0.93 (0.01)***
DGS30	0.79 (0.03)***	0.89 (0.01)***

Table 13: Impacts on financial variables in levels using IV and LS regressions

Note: The table shows the estimates (and standard errors in brackets) from the impact of a 100 basis point shift in the 10-year US Treasury yield (DGS10). One, two and three asterisks indicate significance at the 10%, 5% and 1%, respectively. These regressions follow an ARIMA (1, 0, 1) process, with the exception of DGS20 (1, 0, 0). 2 and/or 5-year Treasuries are used as IVs. All ARMA processes are stationary. The DGS10 coefficient is estimated using the 5-year Treasury.

As one is dealing with time series in levels, serial correlation has to be accounted for. It was found that an ARIMA (1, 0, 1) describes the process more adequately, with the exception of DGS20 where use was made of an ARIMA (1, 0, 0). Invariably a very tight fit was obtained and all the coefficients are statistically significant. The estimators derived for the autoregressive term are in the vicinity of one, thus suggesting that the effects are persistent. A method for evaluating this persistence more properly is to apply a VAR with this data set, as applied by *e.g.* Neelly (2015). A VAR (2), as determined by the Schwarz information criterion and satisfying the stability conditions, was fitted to this daily data set and the pairwise Granger causality test indicates that the 10-year Treasury is a common denominator in Granger causing the other variables, while the joint significance of all other endogenous variables in each of the eight equations estimated is not rejected by the Wald statistic.

With this information on hand, we then estimate the impulse response of a shock (a generalized one standard deviation innovation equal to approximately 5 basis points) to the 10-year Treasury. This innovation is then transmitted to all the other endogenous variables through the dynamic (lag) structure of the VAR. The 10-year Treasury variable was signed (DGS10in) so that a positive surprise represents an easing of monetary policy – the surprise is the relevant yield change multiplied by minus one. The impulse responses obtained are depicted in Figure 7; they should, obviously be interpreted with caution due to the limited predictability of asset prices in dynamic relations.



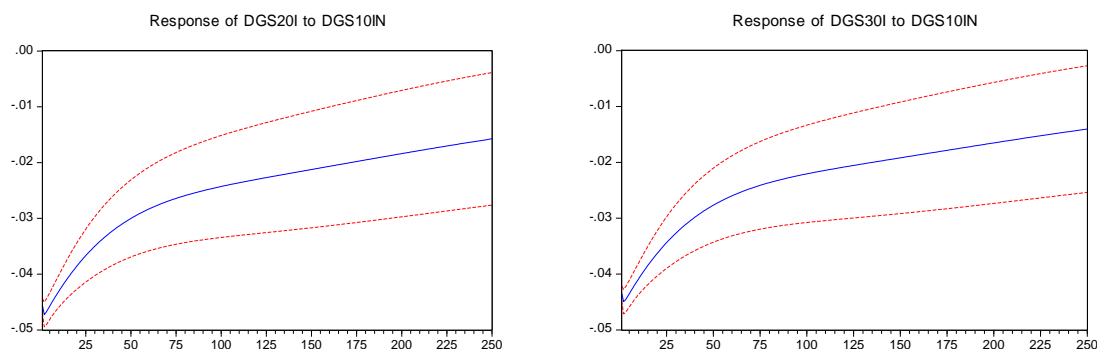


Figure 7: Impulse responses from investment grade bonds and US Treasuries to one standard deviation innovations in the 10-year US Treasury

Note: These graphs plot the daily responses to an innovation of a monetary policy easing consisting of 5 basis points reduction in the 10-year US Treasury. Two standard errors bands about the responses are also shown in dashed lines. The yield changes are in basis points.

The effects of the monetary policy innovation (one standard deviation orthogonal shock) on the securities are noteworthy up to a three-month horizon, in particular with respect to the investment-grade corporate bonds. The persistence then subsides at a very slow pace.

5 Some remarks

The empirical investigation presented herein suggests that monetary policy news during the US ZLB period have significant effects on Treasury yields which, in turn, impact upon other asset prices. This may sound unexpected considering the rising issuance of US Treasuries, as depicted on Figure 8. Total federal public debt raised by some US \$10 trillion between 2007 and late 2015, compared to an increase of less, but obviously massive, than US \$4 trillion in the Fed's total assets consisting mainly of Treasuries. While this may reflect a run for safe-haven assets, the net impact is larger than the Fed's LSAPs and has the opposite sign. Therefore, it would appear that LSAPs have effects over and above the direct effects of reducing the supply of bonds in the market; as mentioned, for instance, in Gertler (2013) and described in Gertler and Karadi (2013), LSAPs are regarded as influencing prices (or yields) by reducing the supply of securities in the market. Arguably, central bank news about LSAPs signal that they will undertake asset purchases and other measures as much as necessary to push term premia and risk premia down and to restore financial stability, namely in the early stages of unconventional monetary policy. See Figure (5)

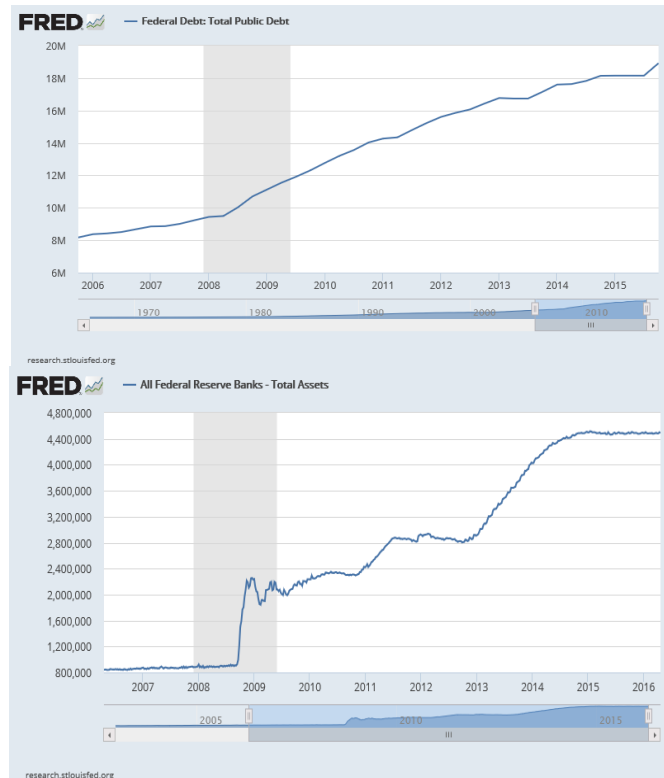


Figure 8: Evolution of public [Federal](#) debt and [Fed](#) assets (in US \$ trillion and \$ million). Source: Fred

When the Fed, or for that matter, a central bank purchases long-term securities in an attempt at enhancing demand, the spill-over effects to other asset prices is crucial to the policy achieving its objectives. Some authors such as Krishnamurthy and Vissing-Jorgenson (2013) argue that these pass-through effects are small. The evidence presented herein suggests otherwise.

Looking ahead, unconventional monetary policies may continue to be warranted. They were discontinued in the US in late 2014, but are still being implemented in the Euro area and Japan at the time of writing (late 2017), though overall global economic conditions after an extended period appear to loom brighter. Nevertheless, their growing scale raises some risks. A key concern is that monetary policy is called upon to do too much, and that the breathing space it allows is not used to engage in needed fiscal, structural, and financial sector reforms. These reforms are crucial to safeguarding macroeconomic stability and entrenching the recovery. Losses to central banks upon exiting are likely to stem from a mismatch between assets and liabilities. Hall and Reis (2017) argue favorably with respect to the unwinding process, at least in the sense that a central bank, in practice, does not go bankrupt. Similarly does Fischer (2015). One can

envisage that a monetary policy tightening will have similar effects to the ones presented, but with a different sign. The evidence collected with the data in this paper points to larger effects from monetary easing than from monetary tightening. A possible interpretation is that with regards to monetary policy easing, the central bank will do whatever it takes to ensure accommodation, whereas downsizing the balance sheet is unlikely to be part of a correspondingly deliberate effort to constrict financial conditions. But, this issue remains an open question. Fischer (2015) claims that the Fed has the tools necessary to remove monetary policy accommodation at the appropriate time and at the appropriate pace. The fact, however, is that while the ZLB was breached in December 2015, the Federal Reserve total assets remain approximately at the same level (some US \$4.5 trillion).

6 In conclusion

The events triggered by the 2007-9 crisis have proved to be some of the most significant economic phenomena observed in high-income economies since, at least, World War II. The main central banks were forced to bring down short-term rates to the zero lower bound, eventually even marginally below. They faced a deflationary vicious vortex as described by several authors, such as Shiller (2013). Furthermore, political and debt restraints substantially reduced the possibility of relying upon fiscal stimulus, thus limiting the options available to monetary and macro prudential policies.

Fortunately, as many authors argue (Bernanke, 2014, Fischer, 2015), monetary policy proved not to be powerless in the face of the zero lower bound. In this paper we study the effects of the Fed's unconventional monetary policies on several financial variables, ranging from government bonds, corporate bonds, and exchange rates to stock returns. An unobservable variable approach, whenever possible, was used and the evidence obtained suggests that these policies were generally effective in bringing down the associated yields. A different methodology grounded on a heteroskedasticity-based approach was also implemented, seemingly upholding these conclusions. An exercise based on a simple dichotomy between easing and tightening monetary policy news is performed; it suggests that monetary easing has higher pass-through effects than monetary tightening, which, as expected, exhibits the opposite sign.

A foray is attempted at trying to disentangle the effects of different types of unconventional policies. Use is made of two multivariate analysis technics. Additionally, we tried to classify the monetary policy events into two separate baskets. Results suggest that LSAP measures are more effective at lowering yields, particularly at longer maturities, while non-LSAP measures, which incorporate FG, lower both Bunds and Gilts yields, and rotate the US yield curve pushing generally short-rates down and long-rates up.

A VAR was fitted to data encompassing several variables in levels (daily observations) and stretching the period 2008-15. Innovations on the 10-year US Treasuries were found to have persistent effects on the other variables that tapered off very slowly, thus suggesting that the flow of monetary policy measures matter

At the time of writing (winter, 2017), the US has ended its unconventional monetary policy programs, but other major high-income countries, particularly in the Euro Area and Japan are still implementing it. This begs the question: What to do if an economic recession hits again, when policymakers have no fiscal maneuver and interest rates remain low or even continue at or slightly below the zero lower bound?

References

- [Bernanke](#), Ben, 2014, “The Federal Reserve: Looking Back, Looking Forward,” Remarks at the Annual Meeting of the American Economic Association, Philadelphia, January, pp. 1-25
- [Bernanke](#), Ben, and Kenneth Kuttner, 2005, “What Explains the Stock Markets Reaction to Federal Reserve Policy?” *Journal of Finance*, 60, pp. 1221-57
- [Bernanke](#), Ben, Jean Boivin, and Piotr Elias, 2005, “Measuring the Effects of Monetary Policy: A Factor-Augmented Auto-Regressive (FAVAR) Approach,” *Quarterly Journal of Economics*, pp. 387-422
- [Cahill](#), M., S. D’Amico, C. Li, and J. Sears, 2014, “Duration Risk versus Local Supply Channel in Treasury Yields: Evidence from the Federal Reserve’s Asset Purchase Announcements,” Day Ahead Conference, FRB Philadelphia, January 2, pp. 1-34
- [D’Amico](#), Stefania, and Thomas King, 2013, “Flow and Stock Effects of Large-Scale Asset Purchases,” *Journal of Financial Economics*, 108, pp. 425-48
- [D’Amico](#), Stefania, William English, David Lopez-Salido, and Edward Nelson, 2012, “The Federal Reserve’s Large-Scale Asset Purchase Programmes: Rational and Effects,” *Economic Journal*, 122, pp. 415-46
- [Eggertsson](#), Gauti, and Michael Woodford, 2003, “Optimal Monetary Policy in a Liquidity Trap,” NBER WP 9968, pp. 1-79
- [Engen](#), Eric, Thomas Laubach, and David Reifschneider, 2015, “The Macroeconomic Effects of the Federal Reserve’s Unconventional Monetary Policy,” *Finance and Economics Discussion Series*, pp. 2015-5
- [Fischer](#), Stanley, 2015, “Conducting Monetary Policy with a Large Balance Sheet,” Remarks at the US Monetary Policy Forum, New York, February 27, pp. 1-16
- [Forni](#), Marco, Marc Hallin, Marco Lippi, and Lucrezia Reichlin, 2000, “The Generalized Dynamic-Factor Model: Identification and Estimation,” *The Review of Economics and Statistics*, 82 4, pp. 540-54
- [Gali](#), Jordi, 2014, “The Effects of a Money-Funded Fiscal Stimulus,” WP September 2014, pp. 1-39
- [Gagnon](#), Joseph, Matthew Raskin, Julie Remache, and Brian Sack, 2011, “The Financial Market Effects of the Federal Reserve’s Large-Scale Asset Purchases,” *International Journal of Central Banking*, 7 1, pp. 1-43
- [Gertler](#), Mark, 2013, “Monetary Policy after August 2007,” *The Journal of Economic Education*, 44 4, pp. 329-38

- [Gertler](#), Mark, and Peter Karadi, 2014, “Monetary Policy Surprises, Credit Costs and Economic Activity,” Prepared for the Conference “Lessons from the Crisis for Monetary Policy” Boston, October 18, 19
- [Gertler](#), Mark, and Peter Karadi, 2013, “QE1 vs. 2 vs. 3...: A Framework for analyzing Large-Scale Asset Purchases as a Monetary Policy Tool,” *International Journal of Central Banking*, 9, pp. 5-53
- [Gertler](#), Mark, and Peter Karadi, 2011, “A Model of Unconventional Monetary Policy,” *Journal of Monetary Economics*, 58, pp. 17-34
- [Gilchrist](#), Simon, David Lopez-Salido, and Egon Zakrajsek, 2015, “Monetary Policy and Real Borrowing Costs at the Zero Lower Bound,” *American Economic Journal*, 7 1, pp. 77-103
- [Glick](#), Reuven, and Sylvain Leduc, 2012, “Central Bank Announcements of Asset Purchases and the Impact on Global Financial and Commodity Markets,” *Journal of International Money and Finance*, 31 8, pp. 2078-101
- [Greenwood](#), Robin, and Dimitri Vayanos, 2014, “Bond Supply and Excess Bond Returns,” *Review of Financial Studies*, 27, pp. 663-713
- [Gurkaynak](#), Refet, Brian Sack, and Eric Swanson, 2005, “Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements,” Munich Personal RePec Archive, pp. 1-47
- [Hall](#), Robert, and Ricardo Reis, 2015, “Maintaining Central Bank Solvency under New Style Central Banking,” NBER WP 21173, pp. 1-54
- [Hamilton](#), James, and Jing Wu, 2012, “The Effectiveness of Alternative Monetary Policy Tools in a Zero Lower Bound Environment,” *Journal of Money, Credit and Banking*, 44 1, pp. 3-46
- [IMF](#) Staff Report, 2013, “Unconventional Monetary Policies – Recent Experiences and Prospects,” Background Paper, pp.1-48
- [Kiley](#), Michael, 2014, “The Response of Equity Prices to Movements in Long-Term Interest Rates Associated with Monetary Policy Statements: Before and After the Zero Lower Bound,” *Journal of Money, Credit and Banking*, 46 5, pp. 1057-71
- [Krishnamurthy](#), Arvind, and Annette Vissing-Jorgensen, 2013, “The Ins and Outs of LSAPs,” FRB of Kansas City Economic Policy Symposium, August 23, pp. 1-44
- [Krishnamurthy](#), Annette, and Annette Vissing-Jorgensen, 2011, “The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy,” NBER WP 17555, pp. 1-54
- [Kuttner](#), Kenneth, 2001, “Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market,” *Journal of Monetary Economics*, 47, pp. 523-44
- [Luciani](#), Matteo, 2009, “Monetary Policy, the Housing Market and the 2008 Recession: A Structural Factor Analysis,” University of Rome, pp. 1-43

- [Meaning](#), James, and Feng Zhu, 2011, “The Impact of Recent Central Bank Asset Purchase Programmes,” BIS Quarterly Review, pp.1-11
- [Neelly](#), Christopher, 2015, “How Persistent are Unconventional Monetary Policy Effects?” FRB of St. Louis, WP 2014-004B, pp. 1-40
- [Reis](#), Ricardo, 2017, “QE in the Future; The Central Bank’s Balance Sheet in a Fiscal Crisis,” IMF Economic Review, 65 1, pp. 71-112
- [Rigobon](#), Roberto, 2003, “Identification through Heteroskedasticity,” The Review of Economics and Statistics, 85 4, pp. 777-93
- [Rigobon](#), Roberto, and Brian Sack, 2004, “The Impact of Monetary Policy on Asset Prices,” Journal of Monetary Economics, 51, pp. 1553-75
- [Rosa](#), Carlo, 2012, “How ‘Unconventional’ are Large-Scale Asset Purchases? The Impact of Monetary Policy in Asset Prices,” FRB of New York Staff Report 560, pp. 17-34
- Sharma, Subhash, 1996, “Applied Multivariate Techniques,” John Wiley & Son pp. 491
- [Shiller](#), Robert, 2013, “Irving Fischer, Debt Deflation and Prices,” Journal of the History of Economic Thought, 35, pp. 179-83
- [Stein](#), Jeremy, 2012, “Evaluating Large-Scale Asset Purchases,” Speech delivered at the Brookings Institution, Washington, October 11, pp. 1-20
- [Swanson](#), Eric, Lucrezia Reichlin, and Jonathan Wright, 2011, “Let’s Twist Again: A High-Frequency Event-Study of Operation Twist and its Implications for QE2, Brookings Papers on Economic Activity, 1, pp.151-207
- [Swanson](#), Eric, 2016, “Measuring the Effects of Unconventional Monetary Policy on Asset Prices,” University of California, Irvine, pp. 1-24
- [Vayanos](#), Dimitri, and Jean-Luc Villa, 2009, “A Preferred Habitat Model of the Term Structure of Interest Rates,” NBER WP 15487, pp. 1-59
- White House, 2015, “Long-Term Interest Rates: A Survey,” Background paper, pp.1-5
- [Wolfson](#), Martin, 1996, “Irving Fisher’s Debt-Deflation Theory: Its Relevance to Current Conditions,” Cambridge Journal of Economics, 20, pp. 315-33
- [Wright](#), Jonathan, 2012, “What does Monetary Policy do at the Zero-Lower Bound,” Economic Journal, 122, pp. 447-66

Chapter 4

The Cases for Money-Financed Stimuli and Negative Nominal Interest Rates

Walking on ice: Monetary policy before and after 2007

The Cases for Money Financed Stimuli and Negative Nominal Interest Rates

Abstract

This paper analyses the effects of fiscal stimuli financed through seignorage, particularly an increase in government spending, a tax rebate, and the issuance of “bonus checks”. A comparison is made with conventional debt-financed stimuli. The results, under appropriate calibration of nominal rigidities and as long as the shocks are not anticipated, suggest that under the former policies, particularly with “bonus checks”, there are strong effects on real economic variables and on welfare, with relatively mild consequences on inflation and also leading to a reduction of the government net debt to output ratio. An experiment to capture a zero lower bound constraint, through an exogenous negative shock to the economy, is performed and the results suggest that an accommodative monetary policy rule under commitment may provide a possible adequate answer, without relying upon fiscal stimuli. Alternatively, money-financed stimuli associated with a policy that brings down nominal short-term interest rates to negative terrain, namely if accompanied with the issuance of “bonus checks”, may lead to positive outcomes, provided that nominal rigidities exhibit high values, as should be expected under extreme conditions of economic duress.

Keywords: fiscal and monetary policy, multiplier effects, seignorage, New Keynesian and Classical models, nominal rigidities, zero lower bound, deterministic and stochastic shocks

JEL codes: E32, E52, E62

1 Introduction

“Let us suppose now that one day a helicopter flies over this community and drops an additional \$1,000 in bills from the sky, which is, of course, hastily collected by members of the community. Let us suppose further that everyone is convinced that this unique event which will never be repeated.” (Milton Friedman, 1969)

Janet Yellen (2016) said in her concluding remarks of a speech delivered in Jackson Hole, Wyoming, that monetary policy will continue to be determinant in supporting a steady and healthy economy. Furthermore, she expects that the new unconventional monetary policy tools, which were introduced to cope with the Great Recession, are probably to remain useful in future, economic slumps; however, she does not discard the use of additional tools and the cooperation with fiscal policy makers.

Indeed, she acknowledges that according to the FOMC projections for the federal funds rate settling at about 3 percent in the longer run, may lead to a lack of maneuverability by the Fed, as on average the fed funds rate dropped by some 5 percent in previous recessions. In this respect, Sims (2016) argues that several recent monetary policy issues can be understood more clearly if the traditional inclusion of the government budget constraint from economic models is relaxed, and calls upon the interaction between fiscal and monetary policy. Moreover, Summers (2016) advances that the prevailing low interest rates in most of the developed economies may be attributed to what he dubs the “secular stagnation”.

Against this background, one may discuss the toolkits that the Fed might use to counter a future slowdown in the US economy. We mention specifically the US, as among the major developed economies is the one that has overcome, thus far, the interest rate lower zero-bound on December 2015; (another exception is the UK that maintains an interest rate in the vicinity of 25 basis points- a reduction from 50 basis points following the Brexit referendum- since August 2016). The ECB, in spite of positive news in terms of a still stuttering economic growth in the EU, maintains at the time of writing (December 2017), a quantitative easing program and the reference deposit facility interest rate remains at -.40 percent. Bernanke (2016) argues that as long as people have the option of holding currency, there are limits to how far the Fed, or for that matter, any major central bank can lower interest rates. Furthermore, this author also suggests that the advantages of low rates may erode over time, while the costs are likely to increase. Consequently, he says, at some point in time, monetary policy may face weakening returns. The scenario of entering into negative interest rates, a reality in some European countries [Rogoff (2014) presents the pros and cons of phasing out paper currency], is an option worth considering and exploring. One can also think of long-term interest rates capping, a practice followed after the World War II by the Fed and studied by Eichengreen and Garber (1991). This last hypothesis is outside this paper’s scope.

When monetary policy alone is insufficient to promote economic recovery or to prevent deflation or too-low inflation, fiscal policy may reveal to be a potentially potent alternative, at least, for possible reoccurrences of the recent crisis. The purpose of this paper is to analyze the effectiveness of an alternate policy, specifically, a fiscal stimulus

financed through money creation without resorting to higher taxes or an increase in government debt, neither in the present nor in the future. We consider four types of money financed stimuli: a tax rebate, an increase in government spending, and the issuance of two types of “bonus checks” impacting differently upon the Euler equation for consumption. We study their effects on several variables, and compare them to the corresponding effects from a conventional debt or tax financed stimulus, with monetary policy decision makers pursuing independently a price-output stability mandate, either through a Taylor rule regime or an inflation targeting process.

The objective of this paper is not to provide an accurate account on the impacts of a money-financed stimulus, but rather to offer a qualitative analysis on the dynamics of such a process, as well as, to arrive at a better understanding of its repercussions, namely when comparing with more orthodox, debt financed methods. Bearing this in mind, we perform the analysis below using very simple frameworks encompassing both a New Keynesian model with monopolistic competition in goods and labor markets and staggered prices and wages, and a frictionless Classical model, characterized by perfect competition and fully flexible prices and wages. Moreover, for simplicity purposes, it is assumed a closed economy with no capital accumulation.

In terms of literature dealing with this topic, the book by the Nobel laureate Friedman (1969), cited above, does not necessarily support the implementation of such measures (but raises the issue); moreover the contexts in the 50s throughout the 90s differed considerably from the present one. More recently, Bernanke (2003) delivered a speech at the Japan Society of Monetary Economics, where he advocated the implementation in Japan, of money-financed fiscal stimulus. Lord Turner (2015 and 2016/7) shares the idea of the potential benefits of monetary financing of fiscal deficits and states that its implementation is essentially a political issue. These authors, however, do not use formal models. Other authors, such as, Reichlin *et al* (2013) also broach qualitatively this subject. Buiter (2014) develops a mathematical formulation and emphasizes the importance of irredeemably of fiat currency; that is, fiat money is an asset for the holder and not a liability for the issuer. He argues that, with money financed boost available, deflation, too-low inflation and secular stagnation, are in practice, policy choices. Galí (2014) develops a DSGE model to study the effects of an increase in government purchases entirely financed through seignorage and concludes

that under certain conditions and adequate calibration, a money financed increase in government spending has very strong effects on economic activity. Tsuruga and Wake (2016) draw significantly on Galí's paper (2014) and show that the success of these policies are dependent upon not being anticipated, otherwise, at the end, the result may be a recession rather than a boom. More recently Galí (2017) reviews his previous 2014 paper to incorporate tax cuts, as well as a ZLB scenario where nominal interest rates are brought down to zero (they cannot fall below this constraint, so he assumes) while real variables fall abruptly due to a large exogenous negative shock to the economy. English *et al* (2017) comment on the possible shortcomings of money financed fiscal programs. This topic on seignorage financed government purchases boost has been referred several times by the press over the last couple of years, such as, The Economist, The New York Times, and Espresso.

One of the main contribution of this study is to complement Buiter (2014) and Galí's studies (2014 and 2017), by extending their analyses to include the issuance of two types of "bonus checks". Moreover, we compare the effects of each of the stimulus under money-financing and debt-financing considering both a Taylor rule regime and inflation targeting regime. Additionally, we extend Galí's (2017) liquidity trap and ZLB constraint analysis by considering as well a monetary policy rule under commitment, following closely Jung *et al* (2005). An experiment is also performed, which combines simultaneously a money financing process with inflation control, or simply considering high levels of frictions that may be attributed to a severe aggregate demand downfall ensued by spiking unemployment; this procedure may be viable under very specific conditions and may (or not) possibly lead to negative nominal interest rates expressed as a deviation from steady state. This may lead to the case for relying upon a less intrusive, when compared with unconventional policies, orthodox policy rule, an hypothesis advanced by Goodfriend (2000, 2016) as delivering the first best measure when dealing with a liquidity trap. Moreover, extending these studies, it is argued that the combination of negative nominal interest rates coupled with fiscal stimuli, in particular in the form of "bonus checks", may prove to be effective in overcoming the zero lower bound constraint, provided that the use of paper money is discontinued. This subject, as far as I know, has not been previously proposed.

The remainder of the paper is organized as follows. Section 2 describes the fiscal and monetary framework to be used in the subsequent analysis, and broaches some analytics on money financed stimuli. Section 3 presents the specifications of a standard key horse New Keynesian Model with price and wage nominal rigidities, as well as, a summary of the main equations entering a frictionless classical model. Section 4 briefly analyzes the effects of money financed stimuli under a frictionless set up. Section 5 extends the previous analysis under a New Keynesian framework and compares them with the results under debt-financing. Section 6 presents a scenario of a liquidity trap under a ZLB constraint. Section 7 considers alternatives available under such a setup including money-financed stimuli and the possibility of implementing negative nominal interest rates associated (or not) with fiscal boosts; moreover it is presented the case for precautionary measures. Section 8 advances some final remarks, summarizes the main findings, and concludes.

2 Fiscal and monetary policy framework

In this section, we present, following Galí (2014) the fiscal and monetary policy context to be included in a simple general model. First, we define the fiscal and monetary decision makers' budget constraints. Then we describe four types of fiscal stimuli under alternative types of financing.

2.1 Budget constraints for policy authorities

The fiscal authority's budget constraint, in real terms is defined by

$$G_t + B_{t-1}R_{t-1} = T_t + S_t^g + B_t \quad (1)$$

where G_t and T_t stand for government expenditures and lump-sum taxes, in real terms, B_t represents the stock in real terms of one period nominally riskless government debt issued in period t and yielding a return i_t , S_t^g is the real transfer from the central bank to the government, and $R_t = (1 + i_t)(\frac{P_t}{P_{t+1}})$, where P_t denotes price. The central bank's budget constraint, where B_t^m stands for government debt held by the central bank, is

$$B_t^m + S_t^g = B_{t-1}^m R_{t-1} + \frac{\Delta M_t}{P_t} \quad (2)$$

where $\frac{\Delta M_t}{P_t}$ is the seignorage obtained in period t . In turn, the amount of debt held by households is

$$B_t^H = B_t - B_t^m, \text{ expressed in real terms} \quad (3)$$

The net government debt, by combining the three previous equations, is given by

$$G_t + B_{t-1}^H R_{t-1} = T_t + B_t^H + \frac{\Delta M_t}{P_t} \quad (4)$$

which may also be seen as an equation in differences describing the path of net government debt in real terms. Consider now, equilibria around the steady state with zero inflation and money growth, no trend growth, and constant net government debt, taxes, and government expenditures. This leads, based on equations (4) and (2), respectively to

$$T = G + \rho B^H \quad \text{and} \quad S^g = \rho B^m \quad (5)$$

where ρ stands for the families' psychological time discount rate, or neutral rate, which in the zero inflation steady state equals the interest rate $i = R - 1$. Thus, in steady state, taxes equal government expenditure plus the cost of servicing the debt, while the central bank revenue from holding debt is transferred to the government.

A key element is to specify the level of seignorage as an expression of steady state output, around zero inflation steady state. In continuous time it can be expressed as

$$S/Y = (\dot{M}/M) (1/V) \quad (6)$$

where S is seignorage, Y is steady state output, and $V = PY/M$ is the steady state income velocity of money. Thus seignorage is a proportion of money growth. In discrete time, it can be approximated by

$$\left(\frac{\Delta M_t}{P_t}\right)(1/Y) \approx (1/V) \Delta m_t \quad (7), \text{ where } m_t = \log M_t$$

Define $\widehat{b}_t^H = (B_t^H - B^H)/Y$, $\widehat{g}_t = (G_t - G)/Y$, and $\widehat{t}_t = (T_t - T)/Y$ as, respectively, deviations of net government debt, government purchases and taxes from their steady state values, specified as a fraction of steady state output. A first order approximation of the consolidated budget constraint (4) around the zero inflation steady state produces a discrete dynamic equation defining the path of net government debt in real terms, articulated as a percentage of steady state output,

$$\widehat{b}_t^H = (1 + \rho) \widehat{b}_{t-1}^H + b^h(1 + \rho)(\widehat{l}_{t-1} - \pi_t) + \widehat{g}_t - \widehat{t}_t - (1/V) \Delta m_t \quad (8)$$

where $\hat{i}_{t-i} = \log((1 + i_{t-1})/(1 + \rho))$, $\pi_t = p_t - p_{t-1}$, and $b^h = B^H/Y$ is the steady state ratio of net government debt to output.

The specification (8) is bound to lead to indeterminacy, as the coefficient on lagged debt is greater than unity, unless, the discount factor (β) equals one. Note that $\rho = (1 - \beta)/\beta$. Thus, as advanced by Galí (2017), consider defining a tax path for \hat{t}_t , with an endogenous component pertaining to deviations of the steady state of the ratio of government debt to output from its targeted state, and an exogenous independent component capturing external shocks, such as, an unanticipated tax rebate also expressed as a net deviation identified as a fraction of steady state output. Specifically, consider the following equation

$$\hat{t}_t = \rho_b \hat{b}_{t-1}^H + \hat{t}^*_t \quad (9)$$

Combining the last two equations one obtains

$$\hat{b}_t^H = (1 + \rho - \rho_b) \hat{b}_{t-1}^H + b^h(1 + \rho)(\hat{i}_{t-1} - \pi_t) + \hat{g}_t - \hat{t}^*_t - (1/V) \Delta m_t \quad (10)$$

As long as, $\rho_b > \rho$, this equation satisfies the Blanchard and Khan's conditions and is convergent, as we will see, based on these assumptions, in all the specifications presented below

2.2 Money-financed and debt-financed fiscal stimuli

As in, *e.g.*, on Galí (2014), we assume that a government spending stimulus, denoted as \hat{g}_t , expressed as a percentage of steady state output, takes the form of an exogenous process, as specified below

$$\hat{g}_t = \rho_g \hat{g}_{t-1} + \varepsilon_t^g \quad (11)$$

where ρ_g , the persistence coefficient, is contained in the interval $[0, 1]$. Assuming that exogenous lump-sum taxes remained unchanged throughout this period, while there is a money financed boost to government spending, then

$$\Delta m_t = V \hat{g}_t \quad (12) \text{ or equivalently } \hat{g}_t = \Delta m_t / V \quad (12a)$$

In other words, the growth of money supply is a multiple of the fiscal stimulus, an exogenous component. A common calibration for the parameter V , the velocity of money in a quarter, is in the vicinity of four. Inserting (12a), into (10), and setting $\widehat{t^*}_t = 0$, then the net debt ratio evolves as follows

$$\widehat{b^H}_t = (1 + \rho - \rho_b) \widehat{b^H}_{t-1} + b^h(1 + \rho)(\widehat{\iota}_{t-1} - \pi_t) \quad (13)$$

Consider, alternatively, a tax rebate $\widehat{t^*}_t$. Note that taxes enter negatively in the government debt ratio, as expected, thus, the exogenous process is defined as a negative shock, capturing the equivalence of a reduction in taxes

$$\widehat{t^*}_t = \rho_t \widehat{t^*}_{t-1} - \varepsilon_t^t \quad (14)$$

Assuming that \widehat{g}_t stays at zero, then

$$\Delta m_t = -V \widehat{t^*}_t \quad (15) \text{ or equivalently } -\widehat{t^*}_t = \Delta m_t / V \quad (15a)$$

Note that, from (14) $\widehat{t^*}_t$ is < 0 , hence $-\widehat{t^*}_t > 0$, and the debt ratio equation (13) remains unchanged, though, not the tax path (9).

Besides a boost in government spending and a tax rebate, we also consider two other fiscal stimuli, in the form of an issuance of “bonus checks” which, in practice, are treated as money financed unexpected increases in government spending; hence they can be treated as specified in equations (11) through (13), switching the term \widehat{g}_t by \widehat{ch}_t where this last expression stands either for \widehat{bcs}_t or \widehat{bca}_t detailed below in (16a) and (16b). The difference lies on the assumption that rather being a drop of e.g., \$100 bills, the checks are payable to named specific households, or for that matter, individuals. The expected increase in aggregate consumption, coupled with sticky prices and wages, will then trigger a variety of general equilibrium effects.

The first type of “bonus check” that we designate bonus check with a shifter [the concept of shifter is described by Galí (2015)], and herein referred as BCs_t [a percentage deviation as a fraction of the steady state output and assuming that in steady state, $BCs = 0$, defined in such a way that its logarithm will yield approximately the percentage deviation of the bonus check in terms of output; formally one may consider $BCs_t = [(\Delta BCs_t + Y)/Y]$ is interpreted as a preference shifter entering multiplicatively the households’ utility function, in the form

$$U(C_t, N_t, \frac{M_t}{P_t})BCS_t \quad (16)$$

where C, stands for consumption, and N is labor. Further details on this function are shown below. It is also considered that \widehat{bcs}_t follows an AR(1) process, where $\rho_{bcs} \in [0,1]$.

$$\widehat{bcs}_t = \log BCS_t = \rho_{bcs} \widehat{bcs}_{t-1} + \varepsilon_t^{bcs} \quad (16a),$$

The second type of “bonus check”, which we refer as BCa_t for adjusted bonus check (also expressed as a percentage deviation as a fraction of the steady state output and as before, $BCa = 0$ in steady state), is taken as impacting directly and additively upon the household’s Euler equation for consumption. The rationale for this proposition rests upon the assumptions made on this type of check. It is an unanticipated, non-transferrable, bonus for the individual, not a liability for the issuer and it contains an expiry date. It must be spent in consumption and serves no other purpose. Thus, it is a rational decision for the individual to do so and “disregard” the Ricardian equivalence constraint embedded in the ensuing DSGE models. Furthermore, computationally, one obtains, as expected, a closed and convergent solution. Note that we are considering that the log of BCa also follows an AR (1) process as in (16a), specifically

$$\widehat{bca}_t = \log BCa_t = \rho_{bca} \widehat{bca}_{t-1} + \varepsilon_t^{bca} \quad (16b), \text{ where } \rho_{bca} \in [0,1], \text{ or alternatively define it as } \widehat{g}_t$$

$$\widehat{bca}_t = (BCa_t - BCA)/Y = BCa_t - BCA = \Delta BCa_t \quad (16c), \text{ following an identical AR (1) process}$$

A more prosaic approach, as advanced later, is merely assuming that $\widehat{bca}_t = \rho^t$, where $\rho \in (0, 1)$ is the persistence factor ($t = 0, 1, 2, \dots$) and the path of the variable, herein interpreted as an unanticipated shock to the economy by private economic agents, is deemed, once it occurs, to be deterministic.

Let us now consider a more conventional scenario, whereby the fiscal stimuli are carried out through the issuance of debt without raising taxes, while an independent central bank executes its mandate to stabilize inflation and output. Assume that the central bank follows a Taylor-type rule

$$\widehat{i}_t = \phi_\pi \pi_t \quad (17)$$

where the coefficient $\phi_\pi > 1$, sets the central bank stance with respect to deviations of inflation from its target level. Alternatively, consider an inflation targeting rule (IT); say $\pi_t = 0$ (17a), which is equivalent to the interest rate Taylor rule, with a very high dislike for inflation or in other words setting the policy coefficient ϕ_π particularly high (in the limit ∞). Note that under either debt-finance regime, money growth is no longer set by the stimuli but, instead by the rule chosen, however, indirectly. Under this background, the net debt ratio evolves according to

$$\widehat{b}_t^H = (1 + \rho - \rho_b) \widehat{b}_{t-1}^H + b^h(1 + \rho)(\widehat{l}_{t-1} - \pi_t) + \widehat{g}_t - (1/V) \Delta m_t \quad (18)$$

where, this equation can be adjusted according to the stimulus decided, assumed not to overlap, specifically \widehat{g}_t , \widehat{bcs}_t or \widehat{bca}_t . For ease of reference, in the case of a tax rebate (18) takes the form

$$\widehat{b}_t^H = (1 + \rho - \rho_b) \widehat{b}_{t-1}^H + b^h(1 + \rho)(\widehat{l}_{t-1} - \pi_t) - \widehat{t}^*_t - (1/V) \Delta m_t \quad (19)$$

3 A New Keynesian and Classical models

3.1 The New Keynesian model

We will now consider, borrowing from Woodford (2003), Galí (2008, 2015), and Walsh (2010) a standard key horse New Keynesian model with price and wage rigidities.

Assume a continuum of monopolistic competitive firms indexed by $i \in [0, 1]$. Each firm produces a differentiated good, but they all use the same technology. Likewise, the economy is populated by a large number of identical households. Each household is made up of a continuum of members, each specialized in specific types of labor is indexed by $j \in [0, 1]$. Each period only the workers specialized in a randomly drawn subset of labor services manage to adjust their nominal wage. In a similar fashion, only a fraction of firms can adjust their prices independently of when they were last reset. As a result, the staggered setting of aggregate nominal wages and prices respond sluggishly to shocks leading to distortions. Next, the problems faced by households and firms, under this setup are described.

3.1.1 Households

An infinitely living representative household tries to maximize its objective utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t, \frac{M_t}{P_t}) = E_0 \sum_{t=0}^{\infty} \beta^t U(\log C_t - \int_0^1 \frac{N(j)_t^{1+\varphi}}{1+\varphi} + \chi \log \frac{M_t}{P_t}) \quad (20)$$

where $C_t = (\int_0^1 C(i)_t^{\frac{\varepsilon p - 1}{\varepsilon p}} di)^{\frac{\varepsilon p}{\varepsilon p - 1}}$ stands for aggregate consumption index, $N(j)_t$ is employment (or working hours) of j-type labor (with $W(j)_t$ the corresponding wage), M_t is money, $P_t = (\int_0^1 P(i)_t^{\frac{1 - \varepsilon p}{1 - \varepsilon p}} di)^{\frac{1}{1 - \varepsilon p}}$ is the aggregate price level, φ determines the curvature of the disutility of labor, β is the psychological discount factor, ε_p (or εp) is the elasticity of substitution among different goods, while χ stands for the weight attributed to real money holdings. Households are subject to a sequence of flow budget constraints and a non-Ponzi scheme

$$\int_0^1 P(i)_t C(i)_t di + Q_t B_t + M_t \leq B_{t-1} + \int_0^1 W(j)_t N(j)_t di + M_{t-1} \quad (21)$$

$$\text{and } \lim_{\tau \rightarrow \infty} E_t(B_\tau + M_\tau) \geq 0 \quad (22), \text{ for all } t$$

where $Q_t = 1 / (1 + i_t)$, and B_t represents the stock of one period nominally riskless government debt issued in period t and yielding a return i_t . Note that each household takes as given labor income ($= \int_0^1 W(j)_t N(j)_t dj$), as, individually, it has no influence on wages or employment, which are set by unions and firms, respectively. Hence, the only decisions available to households are the optimal allocation of consumption among different goods, the optimal intertemporal allocation of consumption, and the choice of money holdings. The resulting optimal choices are

$$C(i)_t = (\frac{P(i)_t}{P_t})^{-\varepsilon p} C_t \quad (23); \text{ furthermore, conditional on this behavior}$$

$$\int_0^1 P(i)_t C(i)_t di = P_t C_t \quad (24)$$

$$Q_t = \beta E_t \left\{ \frac{U_{C,t+1}}{U_{C,t}} \frac{P_t}{P_{t+1}} \right\} \quad (25)$$

$$\frac{M_t}{P_t} = \chi C_t \frac{1 + i_t}{i_t} \quad (26)$$

where (25) and (26) can be represented in log-linearized form as

$$\widehat{c}_t = E_t \{ \widehat{c}_{t+1} \} - (\widehat{l}_t - E_t \{ \pi_{t+1}^p \} - \rho) \quad (27), \text{ where } \pi_{t+1}^p = p_{t+1} - p_t \quad (28)$$

$$m_t - p_t = c_t - \eta \widehat{l}_t + \log(\chi) \quad (29), \text{ where } \eta = \frac{1}{(1+i)i} \approx \frac{1}{\rho} \quad (29a) \text{ is the semi-elasticity of money demand and } \rho = -\log(\beta) \quad (30)$$

Next the problem of wage setting and inflation dynamics is presented.

3.1.1.1 Wage setting and wage inflation dynamics

Consider that each period the nominal wage for workers of any given type remains unchanged with probability $\theta_w \in [0, 1]$. Hence, these workers renegotiating wages in period t , will seek to choose a new wage (W_t^*) in order to maximize their utility function, subject to the sequence of labor demand schedules and flow budget constraints that are effective while W_t^* lasts, specifically

$$\text{maximize } E_t \left\{ \sum_{k=0}^{\infty} (\beta \theta_w)^k U(C_{t+k|t}, N_{t+k|t}, \frac{M_{t+k|t}}{P_{t+k|t}}) \right\} \quad (31)$$

$$\text{subject to } N_{t+k|t} = \left(\frac{W_t^*}{W_{t+k}} \right)^{-\varepsilon_w} N_{t+k} \quad (32) \text{ and}$$

$$P_{t+k} C_{t+k|t} + E_{t+k} \{ Q_{t+k,t+k+1} B_{t+k+1|t} \} + M_{t+k} \leq B_{t+k|t} + W_t^* N_{t+k|t} + M_{t+k-1} \quad (33)$$

where the subscripts $t+k|t$ denote the value of the respective variable in period $t+k$ pertaining to a household that had its wage last reset in period t , while $N_{t+k} = \int_0^1 N_{t+k}(i) di$ stands for aggregate employment in period $t+k$; ε_w or ε_w , used interchangeably, stands for elasticity of substitution among labor varieties. The solution to this problem yields the following equation in logs, expressing the optimal wage setting dynamics

$$w_t^* = \beta \theta_w E_t \{ w_{t+1}^* \} + (1 - \beta \theta_w) (w_t - (1 + \varepsilon_w \varphi)^{-1} \widehat{\mu}_t^w) \quad (34)$$

where $\widehat{\mu}_t^w = \mu_t^w - \mu_w$ represents the deviations of the economy's (in logs) average wage markup $\mu_t^w = (w_t - p_t) - mrs_t$ from its steady state μ_w , where mrs_t denotes marginal rate of substitution. Should one not incorporate wage rigidities in the model, one can obtain the following optimality condition

$$\frac{U_{n,t}}{U_{c,t}} = - \frac{W_t}{P_t} \Rightarrow w_t - p_t = \widehat{c}_t - \varphi \widehat{n}_t = mrs_t \quad (35)$$

$$\text{Letting } W_t = \left(\int_0^1 W(j)_t^{\frac{1-\varepsilon_W}{1}} dj \right)^{\frac{1}{1-\varepsilon_W}} \quad (36)$$

define the aggregate wage index, then the path of wages, given the described wage setting framework, can be defined (in logs) as an equation in differences, specifically:

$$w_t = \theta_w w_{t-1} + (1 - \theta_w) w_t^* \quad (37)$$

Using equations (34) and (37), and defining wage inflation as $\pi_t^w = w_t - w_{t-1}$, the baseline wage inflation dynamics is given by

$$\pi_t^w = \beta E_t \{ \pi_{t+1}^w \} - \lambda_w \widehat{\mu}_t^w \quad (38)$$

where $\lambda_w = (1 - \theta_w)(1 - \beta\theta_w)/[\theta_w(1 + \varphi\varepsilon_w)]$. Note that equation (38) replaces the optimality condition expressed in equation (35), as the average real wage will not move one for one with the marginal rate of substitution.

Now let us consider the problem of firms.

3.1.2 Firms

A representative monopolistic competitive firm is assumed to have a technology described by a Cobb-Douglas production function of the type

$$Y(i)_t = A_t N(i)_t^{1-\alpha} \quad (39)$$

where $Y(i)_t$ denotes the output of good i , A_t stands for the level of technology common to all firms, and $a_t = \log A_t$ evolves exogenously as a stochastic process ($\widehat{a}_t = \rho_a \widehat{a}_{t-1} + \varepsilon_t^a$) (40), $N(i)_t$ is an index of labor input used by firm i in period t and defined by

$$N(i)_t = \left(\int_0^1 N(i,j)_t^{\frac{\varepsilon_W-1}{\varepsilon_W}} dj \right)^{\frac{\varepsilon_W}{\varepsilon_W-1}} \quad (41)$$

where $N(i,j)$ represents the quantity of type j labor working for firm i in period t .

Letting $W(j)_t$ denote the nominal wage for type j labor prevailing in period t one can derive the demand schedule for each firm i and labor type j , given the firm's total employment, as well as, the wage bill

$$N(i, j)_t = \left(\frac{W(j)_t}{W_t}\right)^{-\varepsilon_W} N(i)_t \quad (41a) \quad \int_0^1 W(j)_t N(i, j)_t dj = W_t N(i)_t \quad (42)$$

Assuming that in each period a fraction of firms $(1 - \theta_p)$ manages to change its prices, a firm adjusting its price in period t , conditional on an optimal allocation of the wage bill determined by (42), will face the following profit maximization problem

$$\max_{P_t^*} \sum_{k=0}^{\infty} \theta_p^k E_t \{ \Lambda_{t,t+k} (1/P_{t+k}) (P_t^* Y_{t+k|t} - q_{t+k} Y_{t+k|t}) \} \quad (43)$$

$$\text{subject to a sequence of demand functions } Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\varepsilon_p} C_{t+k} \quad (44)$$

where $\Lambda_{t,t+k} = \beta^k U_{c,t+k} / U_{c,t}$ is the stochastic discount factor, $q_t(\cdot)$ is the nominal cost function, and $Y_{t+k|t}$ represents output in period $t+k$ for a firm that last reviewed its price in period t . The solution to this problem yields to a first order approximation around a zero inflation steady state an equation for price inflation $\pi_t^p = p_t - p_{t-1}$ (45), the log difference of prices, as follows

$$\pi_t^p = \beta E_t \{ \pi_{t+1}^p \} - \lambda_p \widehat{\mu}_t^p \quad (46)$$

where $\lambda_p = \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p} \frac{1-\alpha}{1-\alpha+\alpha\varepsilon_p}$ and $\widehat{\mu}_t^p$ is the deviation of the average price markup in logs from its flexible rule counterpart.

3.1.3 Equilibrium

In equilibrium goods market clearing requires that $Y(i)_t = C(i)_t + G_t$ where $Y_t = (\int_0^1 Y(i)_t^{\frac{\varepsilon_p-1}{\varepsilon_p}} di)^{\frac{\varepsilon_p}{\varepsilon_p-1}}$. It is assumed for simplification purposes and without loss of generality that in steady state $G = 0$. It follows that $Y_t = C_t + G_t$ and in deviations from steady state, as a fraction of steady state output

$$\hat{y}_t = \hat{c}_t + \hat{g}_t \quad (47)$$

Aggregate output can be derived from equation (39) and yields up to a first order approximation an equation relating output and labor demand, given technology

$$\hat{y}_t = (1 - \alpha) \widehat{n}_t + \widehat{a}_t \quad (48)$$

Next introduce the concepts of output gap and real wage gap. The former is defined as the difference between output and natural output, which is to be interpreted as the equilibrium level of output in the absence of nominal rigidities

$$\tilde{y}_t = \hat{y}_t - y_t^n \quad (49) \text{ and } y_t^n = \Psi_{ya} a_t + \Psi_y \quad (50)$$

where $\Psi_{ya} = \frac{1+\varphi}{(1-\alpha)+\varphi+\alpha}$ and $\Psi_y = (1-\alpha) \frac{\log(1-\alpha)}{1+\varphi}$

Likewise, the real wage gap is described as the difference between the real wage and natural real wage, where $\omega_t = w_t - p_t$. Formally

$$\tilde{\omega}_t = \omega_t - \omega_t^n \quad (51)$$

where $\omega_t^n = \Psi_{wa} \hat{a}_t + \Psi_w$, $\Psi_{wa} = \Psi_{ya}$, and $\Psi_w = \frac{(1-\alpha+\varphi)\log(1-\alpha)}{1+\varphi}$

The introduction of these two variables (output gap and real wage gap) allows us to write (38) and (46) respectively as:

$$\pi_t^p = \beta E_t \pi_{t+1}^p + k_p \tilde{y}_t + \lambda_p \tilde{\omega}_t \quad (52)$$

$$\pi_t^w = \beta E_t \pi_{t+1}^w + k_w \tilde{y}_t - \lambda_w \tilde{\omega}_t \quad (53)$$

where $k_p = \frac{\alpha\lambda_p}{1-\alpha}$ and $k_w = \lambda_w(1 + \frac{\varphi}{1-\alpha})$

Additionally, consider the following identity:

$$\tilde{\omega}_t = \tilde{\omega}_{t-1} + \pi_t^w - \pi_t^p - \Delta \omega_t^n \quad (54)$$

In order to complete the non-policy block of the model, equilibrium conditions (52), (53), and (54) must be supplemented with a dynamic IS equation, which can be derived by combining the goods market clearing condition $\hat{y}_t = \hat{c}_t + \hat{g}_t$ (47) with Euler equation (27). The resulting equation is rewritten in terms of the output gap as

$$\tilde{y}_t = E_t \tilde{y}_{t+1} - (\hat{i}_t - E_t \pi_{t+1}^p - r_t^n) \quad (55)$$

where the real interest rate $\hat{r}_t = \hat{i}_t - E_t \pi_{t+1}^p$ (56) and the natural interest rate $r_t^n = \rho + E_t \Delta y_t^n$ (57)

Finally, in order to close the model, one has to specify how the nominal interest rate is determined. In this regard, assume an interest rate rule of the form

$$i_t = \rho + \phi_p \pi_t^p + \phi_w \pi_t^w + \phi_y \tilde{y}_t + v_t \quad (58)$$

where ϕ_p , ϕ_w , and $\phi_y \geq 0$ are coefficients defined by the monetary authority, while v_t is an exogenous variable, possibly a function of r_t^n and $\Delta\omega_t^n$, and normalized such that its mean is zero.

In order to arrive at computational treatment (Dynare / Matlab), the following log linearized equations (dropping isolated constants) can be used under a TR process: (28), (29), (40), (47), (48), (49), (50), (52), (53), (54), (55), (56), (57), and (58). Under the IT regime, use equation (17) instead of (58). These two hypotheses correspond to a debt-financed fiscal stimulus consisting of an unannounced tax rebate or government spending, each considered separately. Therefore, two equations specifying the AR (1) process for each of them have to be added to the model, specifically (11) and (14). The net debt ratio can also be incorporated using equation (18) that has to be adjusted for the type of stimulus being applied.

Should one want to consider money-financed government spending or tax rebate instead, simply drop (58) or (17) and insert (12) adjusted accordingly; equation (18) should also be replaced by (13).

In the case of issuance of either money or debt financed “bonus checks”, additional specifications are required. Under a “milder” scenario the “bonus check” is treated as a shifter affecting multiplicatively the representative household’s utility function as follows

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t, \frac{M_t}{P_t}) \quad BC_{St} = E_0 \sum_{t=0}^{\infty} \beta^t U(\log C_t - \int_0^1 \frac{N(j)_t^{1+\varphi}}{1+\varphi} + \chi \log \frac{M_t}{P_t}) \quad BC_{St} \quad (59)$$

One of the household’s optimality conditions resulting from the maximization of this equation subject to a budget constraint (22) is given by

$$Q_t = \beta E_t \left\{ \left(\frac{C_t}{C_{t+1}} \frac{P_t}{P_{t+1}} \frac{BC_{St+1}}{BC_{St}} \right) \right\} \quad (60)$$

which can be expressed as a log-linear approximation around a steady state with constant rates of inflation and consumption growth, as shown

$$\widehat{c}_t = E_t \{ \widehat{c}_{t+1} \} - (i_t - E_t \{ \pi_{t+1}^p \} - \rho) + (1 - \rho_{bcs}) \widehat{bcs}_t \quad (61); \text{ thus the output gap becomes}$$

$\tilde{y}_t = E_t\{\tilde{y}_{t+1}\} - (\hat{i}_t - E_t\{\pi_{t+1}^p\} - r_t^n) + (1 - \rho_{bcs}) \widehat{bcs}_t$ (62), which replaces (55) in the script

Note that the way this preference shifter enters the utility function, it affects only the intertemporal choices through $U_{c,t+k} / U_{c,t}$, the intertemporal marginal rate of substitution, and has no bearing on intratemporal choices as $U_{c,t} / U_{n,t}$ and $U_{c,t} / U_{m,t}$ remain unchanged.

In the case of a “stronger bonus check” version, it is assumed that it impacts directly and additively on the consumer’s Euler equation. He or she simply has no choice, but to spend it immediately (it has no storage value), no matter how trivial the options might be. Thus (61) and (62) become

$$\hat{c}_t = E_t\{\widehat{c}_{t+1}\} - (\hat{i}_t - E_t\{\pi_{t+1}^p\} - \rho) + \widehat{bca}_t \quad (63)$$

$\tilde{y}_t = E_t\{\widetilde{y}_{t+1}\} - (\hat{i}_t - E_t\{\pi_{t+1}^p\} - r_t^n) + \widehat{bca}_t$ (64), which replaces (55) in the script.

Additionally, note that $\Delta m_t = V \widehat{bcs}_t$ (65) and $\Delta m_t = V \widehat{bca}_t$ (66), while both \widehat{bcs}_t and \widehat{bca}_t follow an AR (1) process subject to exogenous shocks. Thus, these specifications, as well as (65) and (66) (separately) should be added to the model.

And this completes the basis for the computational scripts. All that is required to make it running is to specify the shock, which has been calibrated invariably at 1 percent of steady state output, the exception being the tax rebate stimulus, which by definition enters with a negative sign.

3.2 Classical frictionless model

Here we consider the summary of a simple model covering an increase in government spending in a classical monetary economy set up (for other stimuli, simply adjust accordingly), exhibiting perfect competition and fully flexible prices in all markets. As it will be seen below, many of the results and predictions of such an economy are strongly at odds with the empirical evidence; thus, this model mainly serves for comparison purposes as a limit case of a New Keynesian set up.

The departing functions, namely the utility, production, and budget constraint functions are similar to those above, adjusted obviously for the new assumptions concerning perfect competition. Consumers’ and firms’ optimality conditions yield

equations (I) through (IV) (all variables are expressed in logs or percentage deviations from the steady state, represented by lower case letters with a hat, while isolated constants are dropped)

$$\widehat{c}_t = E_t \{ \widehat{c}_{t+1} \} - (\widehat{l}_t - E_t \{ \pi_{t+1} \}) \quad \text{(I); adjust accordingly}$$

$$\widehat{\omega}_t = \widehat{c}_t + \varphi \widehat{n}_t \quad \text{(II)}$$

$$m_t - p_t = \widehat{c}_t - \eta \widehat{l}_t \quad \text{(III)}$$

$$\widehat{\omega}_t = \widehat{a}_t - \alpha \widehat{n}_t \quad \text{(IV); additionally consider}$$

$$\pi_t = p_t - p_{t-1} \quad \text{(V): definition of inflation}$$

$$\widehat{y}_t = \widehat{c}_t + \widehat{g}_t \quad \text{(VI): market clearing}$$

$$\widehat{y}_t = \widehat{a}_t + (1 - \alpha) \widehat{n}_t \quad \text{(VII): production function mapping } n_t$$

$$\widehat{r}_t = \widehat{l}_t - E_t \{ \pi_{t+1} \} \quad \text{(VIII): Fisher identity}$$

$$\widehat{a}_t = \rho_a \widehat{a}_{t-1} + \varepsilon_t^a \quad \text{(IX): assumption}$$

$$\widehat{g}_t = \rho_g \widehat{g}_{t-1} + \varepsilon_t^g \quad \text{(X): assumption; adjust accordingly}$$

$$\Delta m_t = m_t - m_{t-1} \quad \text{(XI) definition}$$

$$\Delta m_t = V \widehat{g}_t \quad \text{(XII): money financed stimulus (adjust accordingly). Or instead,}$$

$$\widehat{l}_t = \phi_\pi \pi_t \quad \text{(XIII): debt financed stimulus with a Taylor rule. Or instead,}$$

$$\pi_t = 0 \quad \text{(XIV): debt financed stimulus under IT}$$

This completes the model, which can now be submitted to exogenous shocks. Other specifications may be included, such as the net debt ratio, nominal wages, and the explicit money demand, among others.

3.3 Calibration and the inclusion of other variables

The default calibrations, unless stated otherwise, follow essentially Galí (2014, 2015, 2017), and are common in the literature. The discount factor β is set somewhat higher at 0.995, which entails an annualized steady state real return on financial assets in the vicinity of 2 percent, more in consonance with the prevailing environment. It is assumed that $\sigma = 1$, which means that it is considered a logarithm function for consumption in the utility definition. The curvature of labor disutility, ϕ , is 5, which means that Frisch elasticity of labor supply is 0.2. Parameter α (decreasing returns to labor) equals 0.25, while the ratio G/Y designated σ_g is assumed to be 0 in steady state (for simplicity sake, at least in terms of algebraic calculation, $G = 0$). η (interest rate semi-elasticity of money demand) is set at 7 (consistent with quarterly interest rates as used in the model) and V (quarterly velocity of money) is set at 3, while $b^h = 2.40$, corresponds to a 60 percent ratio of debt to annual output. The persistence ratio ρ_x for all the variables subject to a shock equals 0.5, a setting associated with a moderately persistent shock, while $\rho_b = 0.105$ used in the tax path (9) and in the net debt ratio equation of motion (10), allows the first coefficient on the right hand side of (10) to equal 0.90; that is $1 + \rho - \rho_b = 0.90$, which is reasonably close to the derivation obtained in (8), equaling $(1 + \rho = 1.005)$. In practical terms this means that roughly one-third of the deviation of the debt ratio from target is corrected over four periods, which appears to be ambitious if the net debt ratio is high; formally ρ_b it is the solution to the equation $[1 + \rho (= 0.005) - \rho_b] = (1 - \frac{1}{3})^{1/4}$; see for instance, Anderson *et al* (2014).

In respect to θ_p , and θ_w , the indexes of prices and wages rigidities, they are both set at 0.75, meaning that prices and wages have an average duration of four quarters. Considering the wage elasticity of substitution for labor (ε_w) and price elasticity for goods (ε_p), it is assumed that they take the values of 4.5 and 9, respectively. Consequently wage (μ_w) and price gross markups (μ_p) equal respectively 1.28, and 1.125, entailing an unemployment level of 5 percent and an average 12.5 percent price markup in steady state (see Galí, 2015, for the derivation of these values). Obviously, in the classical setting, the markup equals unity and rigidities are zero. Finally, ϕ_π in the Taylor rule, is set at 1.5.

Following Galí (2014), we incorporate in the models another function designated *welfare*, which aims to capture the impacts of the fiscal stimuli on the well-being of households measured by the utility function. With that in mind, a first order Taylor approximation around the steady state is carried out, as follows

$$\begin{aligned}\widehat{U}_t &= U_c C \widehat{C}_t + U_n N \widehat{n}_t + U_m (M/P) \widehat{l}_t \\ \widehat{U}_t &= U_c C [\widehat{C}_t - \text{MRS}(N/C) \widehat{n}_t + \frac{U_m}{U_c} (\frac{M/P}{C}) \widehat{l}_t] \\ \widehat{U}_t &= U_c C [\widehat{C}_t - (\frac{\text{MRS}}{\text{MPN}}) (\frac{1-\alpha}{1}) \widehat{n}_t + (\frac{1-\beta}{V}) \widehat{l}_t] \\ \widehat{U}_t &= U_c C [\widehat{C}_t - (\frac{1-\alpha}{\mu}) \widehat{n}_t + (\frac{1-\beta}{V}) \widehat{l}_t] \quad (67)\end{aligned}$$

where MRS is marginal rate of substitution, MPN is marginal productivity of labor, μ is the composite markup $\mu_p \mu_w$, and $\widehat{l}_t = m_t - p_t$ denotes money demand in deviation from steady state.

While this indicator is dependent upon the paths of consumption, labor, and albeit marginally, money demand, one may question the effectiveness of the shocks in terms of consumption (call it *dynamic consumption multiplier, DCM*), while assessing the effects in terms of benefits (additional consumption) versus the costs proxied by increases in inflation (call it the *inflation-consumption tradeoff ratio, CTO*). These statistics are calculated as follows

$$\text{DCM}(k) = (\sum_{j=0}^k \frac{\partial \widehat{C}_{t+j}}{\partial \varepsilon^x_t}) / (\sum_{j=0}^k \frac{\partial x_{t+j}}{\partial \varepsilon^x_t}) \quad (68)$$

where x stands for the four types of stimuli, $k = 0, 1, 2, \dots$. The tradeoff ratio is computed as

$$\text{CTO}(k) = (\sum_{j=0}^k \frac{\partial \widehat{C}_{t+j}}{\partial \varepsilon^x_t}) / (\sum_{j=0}^k \frac{\partial \pi_{t+j}}{\partial \varepsilon^x_t}) \quad (69)$$

Note that the higher the values of these statistics, the better off are households, in a comparable manner as the welfare indicator shows (67). Similarly, one can calculate analogous statistics for other relevant variables, such as output, net debt ratio, and welfare.

4 The effects of fiscal stimuli in a classical frictionless model

We will now consider separate shocks of 1 percent in each of the four fiscal stimuli, under the three different financing regimes. The first is a money financed boost, while the other two are debt financed under a Taylor rule and an inflation targeting frameworks. What immediately captures the attention is that the equilibrium dynamics of the real block of the model, consisting of variables such as consumption, employment, and output are determined independently of the financing regime, though not of the type of stimulus. Thus, the financing regime is neutral as it should be expected based on the specifications of the model. For illustrative purposes, see Figure 1 below, where the fiscal stimuli are designated BCa, BCs, G, and TR.

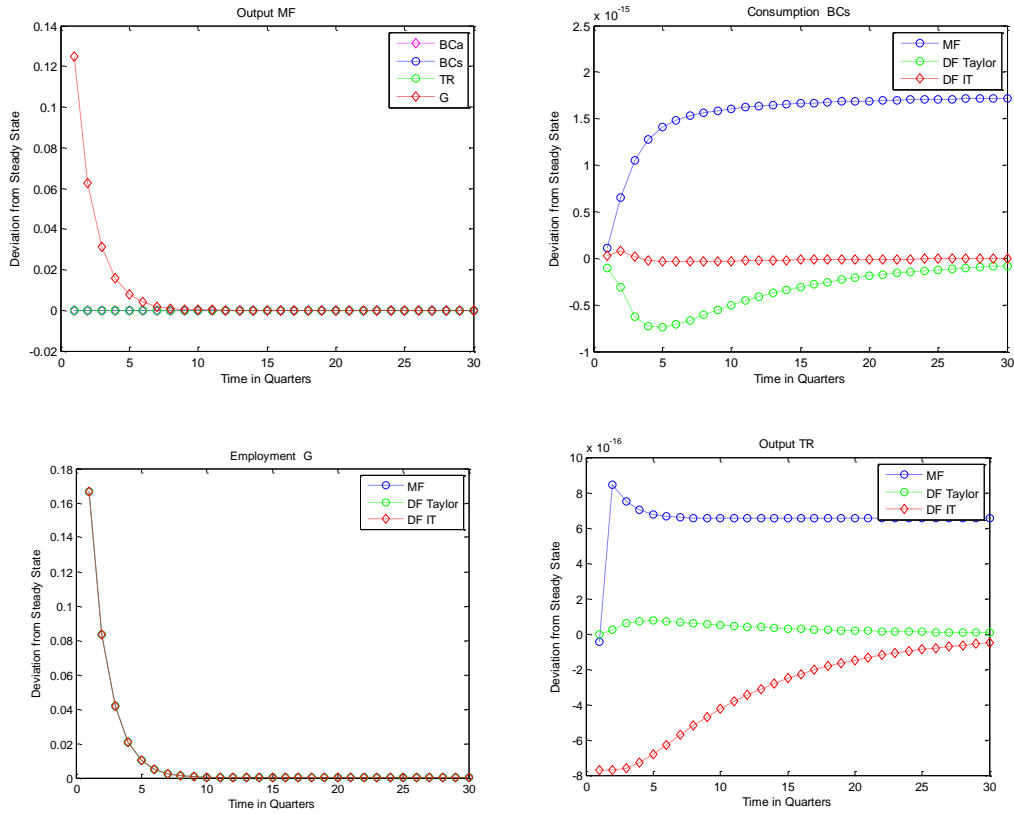


Figure 1: Effects of Four Fiscal Stimuli on four Different Real Variables in a Classical Economy

At a first glance, figures 1.2 and 1.4 are deceptive, because responses are raised to the power of at least 10^{-15} . In turn, figures 1.1 and 1.3 reveal that the path of real rates and employment are the same. Another message to retain is that, under these specifications, with the exception of a boost in government spending, output,

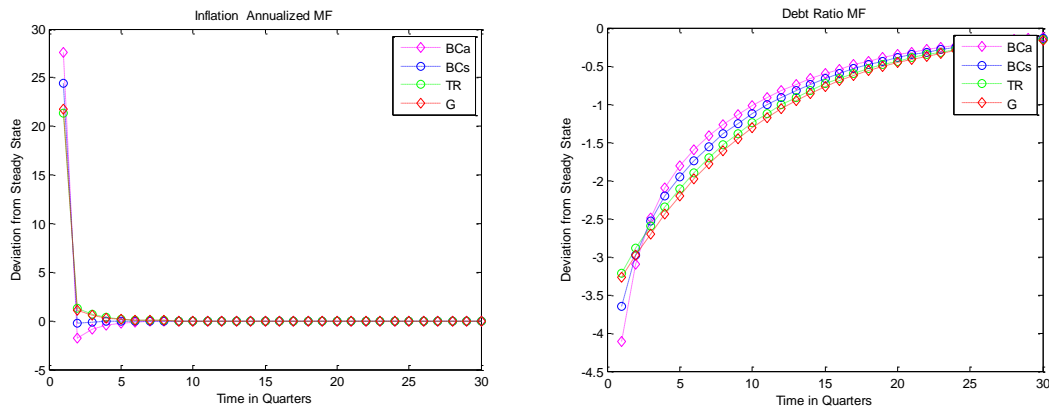
consumption, and employment (a linear log combination of output) simply do not bulge under the other three stimuli. A tax rebate does not enter in the output definition; hence it does not affect it, as well as neither employment nor consumption. The issuance of “bonus checks” of either type, while entering output through the component $[(1 - \rho_{bcs}) \widehat{bcs}_t \text{ or } \widehat{bca}_t]$ in the Euler equation for consumption is exactly offset by the increase in the real interest rate. Consider the case of a “bonus check with a shifter”. Then,

$$\widehat{\Delta c_{t+1}} = \widehat{r}_t - (1 - \rho_{bcs}) \widehat{bcs}_t = 0 \quad (70), \text{ as } \widehat{r}_t = \widehat{l}_t - E_t\{\pi_{t+1}\} = (1 - \rho_{bcs}) \widehat{bcs}_t$$

With respect to an increase in government spending, there are, however small, some effects. For instance, one can establish a relation between employment, output, and consumption as a function of government spending as follows

$$\widehat{n}_t = \widehat{g}_t / (1 + \varphi) > 0 \quad (= 0.17) \quad (71) \Rightarrow \widehat{y}_t = (1 - \alpha) \widehat{n}_t > 0 \quad (= 0.125) \Rightarrow \widehat{c}_t = \widehat{y}_t - \widehat{g}_t < 0 \quad (= -0.875)$$

In short, real variables can be calculated independently of the nominal variables, which have to be pinned down, in order to avoid multiple equilibria. This is accomplished directly through the definition of the money financing regime, or indirectly, through the monetary policy rule. Once, this is done, it can be seen that money financed fiscal stimuli, flow mainly through the nominal variables, as shown in Figure 2.



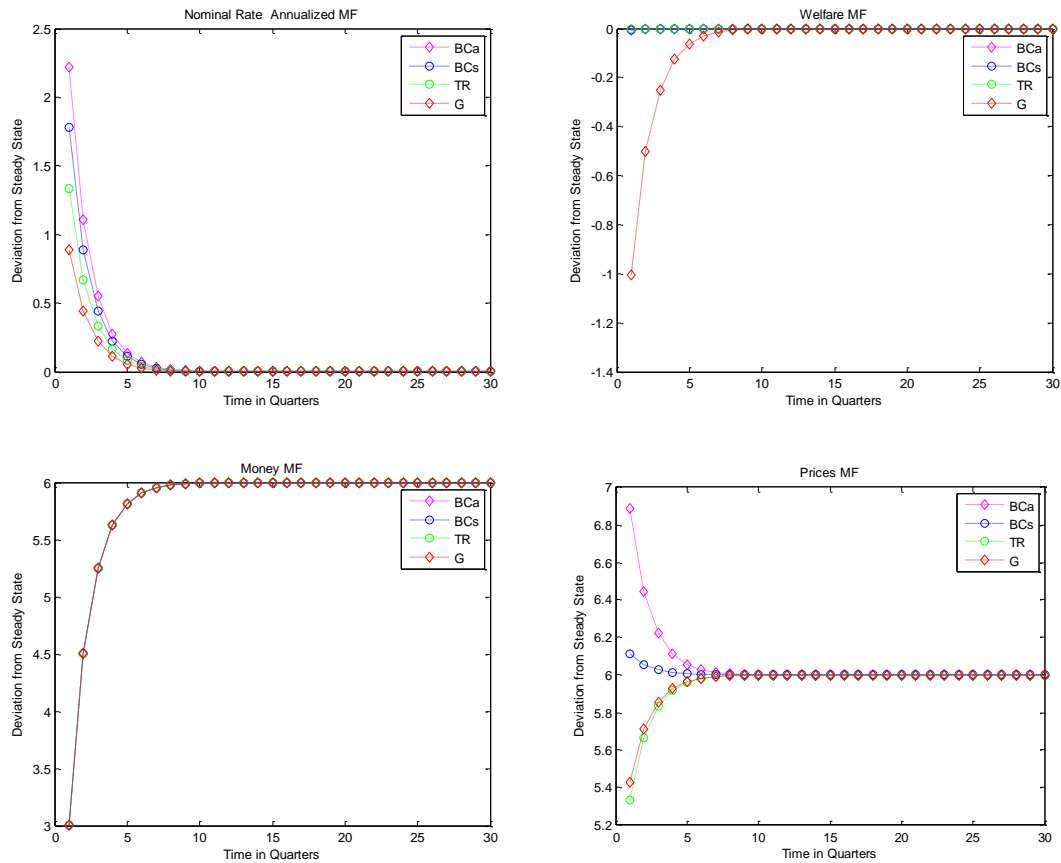


Figure 2: Effects of Four Money-Financed Fiscal Stimuli on Selected Nominal Variables in a Classical Economy

On impact, money raises by 3 percent (that is money velocity times the shock) reaching 6 percent by the seventh period, while prices grow by a multiple of money ranging from some 5 percent under a tax rebate to near 7 percent under an unadjusted “bonus check”, and converge to a new platform at 6 percent. This translates into a spike in the annualized inflation rate ranging from some 24 percent to 28 percent, which then falls precipitously in the second period. These impacts bring down vigorously the net debt ratio, which falls between 3 and 4 percent, at the onset, and then moves up gradually according to the equation of motion (13), adjusted for quarterly values. Furthermore, the path of inflation entails that nominal interest rates move up by 1 to 2 percent before stabilizing at zero by seventh period. On the other hand, welfare, which is included as a nominal variable due to the presence of money holdings, remains flat, with the exception of a boost to government spending; in this case it falls due mainly to a decrease in consumption and an increase in employment (see 71).

Should one consider a debt financed boost, then the paths of the nominal variables are brought “under control”, particularly under an inflation targeting regime, while real variables as indicated remain unchanged.

To summarize, under the unrealistic assumption of a frictionless classical set up, money-financed fiscal stimuli merely translate into higher prices, more money in circulation, and an inflation scare. There is only one set of good news: the fall in the net debt ratio and some information to be used for comparison purposes, with a more feasible scenario, where prices and wages do not move immediately or fully, following an exogenous impact.

5 The effects of fiscal stimuli in a New Keynesian model

5.1 An adjusted “bonus check”

Consider now, a New Keynesian model with staggered prices and wages *a la* Calvo, which will translate into meaningful dynamic impacts on some relevant variables. In this subsection it will be covered the impact of the increase in government spending of 1 percent of output taking the form of an adjusted “bonus check” issued, unanticipatedly, to households. Recall that the rationale for this type of instrument, is that, it is meant strictly for consumption and nothing else but consumption, to be used within a limited time frame. Hence, it is appended directly into the consumption Euler equation; there is no omnipresent, omniscient representative agent who could foretell an unanticipated bonus of this type and fails to react. It is the equivalent of a higher net worth circumscribed by a time factor. A comparison is made for the three financing regimes, as shown on Table 1 and Figure 3.

	Dynamic Consumption Multiplier			Consumption Tradeoff Ratio		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
MF	6.24	11.86	19.40	9.64	8.34	7.29
DF-Taylor	1.89	1.84	1.78	48.73	35.62	26.95
DF-IT	0	0	0	0	0	0

Table 1: The Effects of a Bonus Check (Adjusted) in the New Keynesian Economy: Money vs. Debt Financing

The introduction of rigidities in the specification of this model translates into significant changes when comparing with the classical setup as depicted in Figure 3. There is now a dynamic interaction between real and nominal variables, particularly noticeable under a seignorage process.

The effect of an unannounced money-financed increase in government expenditures on output, welfare, and employment is larger than in a classical economy set up, with multipliers reaching on impact, respectively, some 6, 2, and 8 percent. These multipliers are higher than those found in the literature (see, *e.g.*, Ramsey 2011, for a study and review of fiscal multipliers), though the model advanced here, as far as I know, does not have an empirical counterpart in recent history. Moreover, these multipliers taper off slowly; for instance, looking at Table 1, it can be seen that the dynamic consumption multiplier (accumulated diminishing ratios) increases from about 6 percent in the first period to around 19 percent in the fifteenth period. This comes at an acceptable cost: inflation moves up by 2.60 percent (annualized), however a much lower value than the one arrived under the classical model (25 percent) and in line or closer to the levels pursued by major central banks (2 to 2.5 percent on average). One year after the boost, inflation drops to 2 percent. Overall, however, the consumption tradeoff ratio reveals positive values

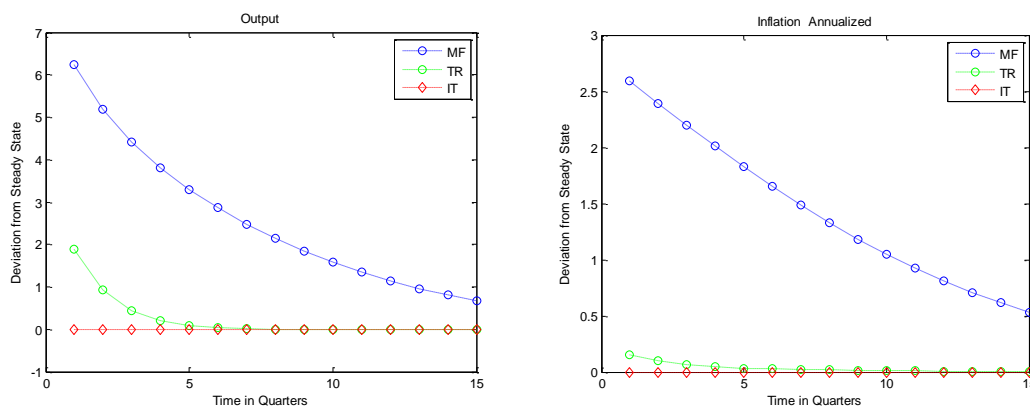
Note also that the path of money remains the same, but prices, due to stickiness, evolve slower and only reach a steady value (6 percent increase) by the thirtieth period. Gradualism in the pace of prices seems to play a main part in the in the transmission process of the money financed lift. Indeed, there is a persistent reduction in the real interest rate, which is conducive to higher levels of consumption (and investment not included in the model) and thus, to a large fiscal multiplier. On the other hand the increase in the nominal interest rate coexists with a reduction in the real interest rate. This increase is due to higher consumption bounded by a higher money demand ($m > p$). The difference between the two rates is explained by a persistently higher level of inflation, which is accounted for by the gradual adjustment in prices, as opposed to the classical economy, which exhibits one-off jump in inflation.

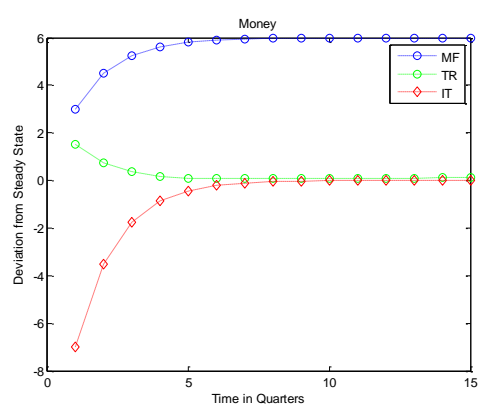
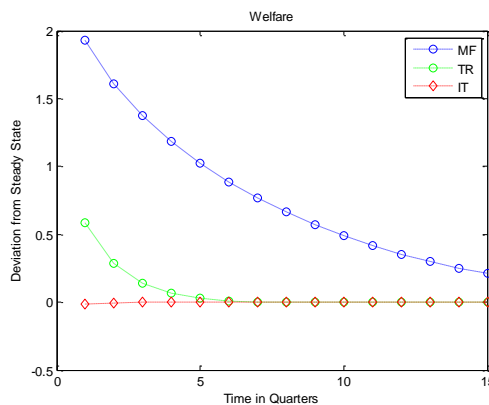
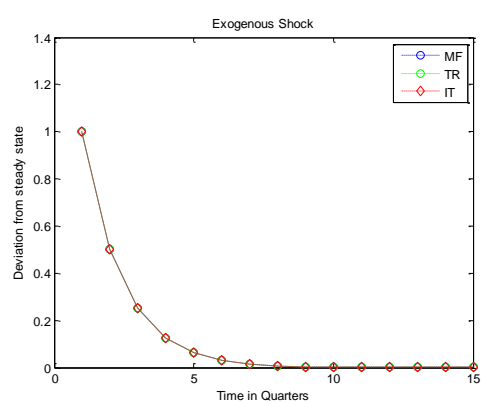
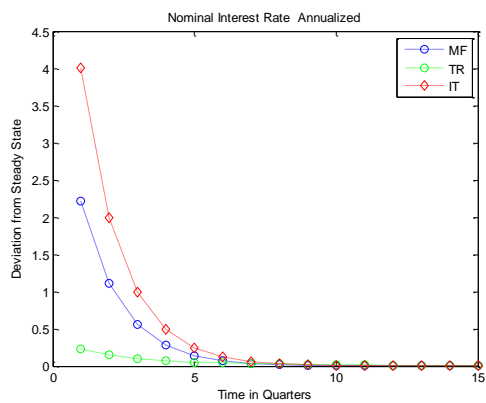
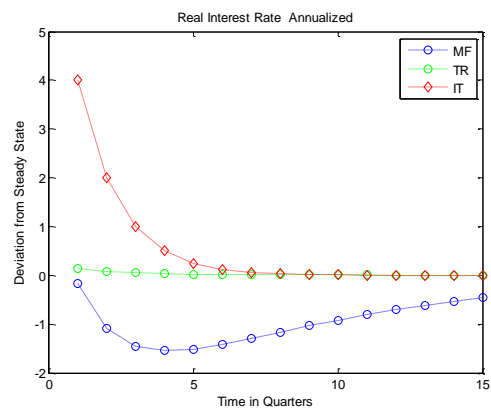
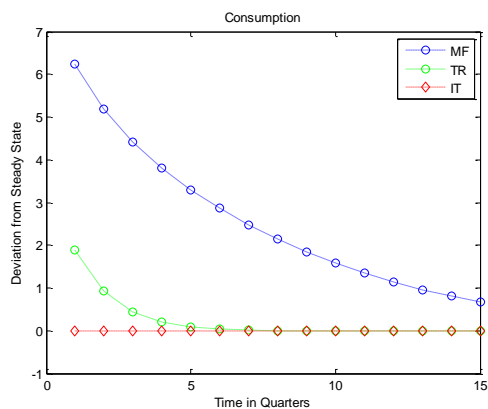
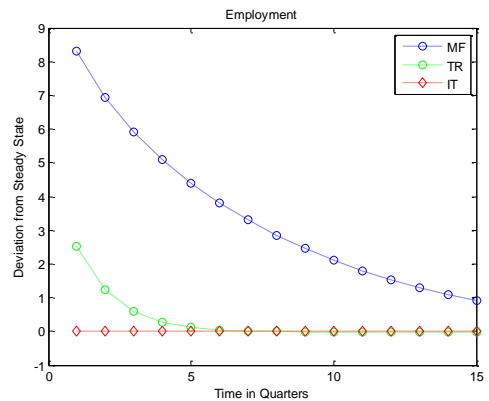
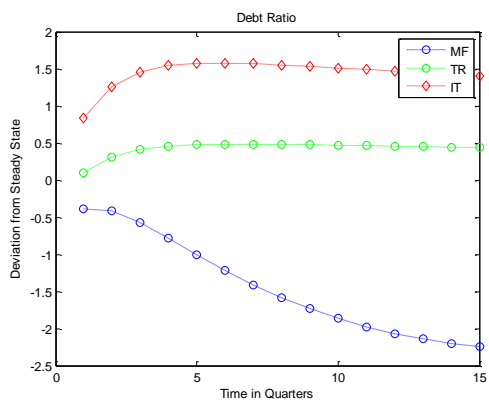
Additionally, it can be seen that the debt ratio while decreasing, does not reach the levels as in the classical economy. This is can be explained by the difference in the inflation rates, which account for the change in the erosion of debt, as well as by lower

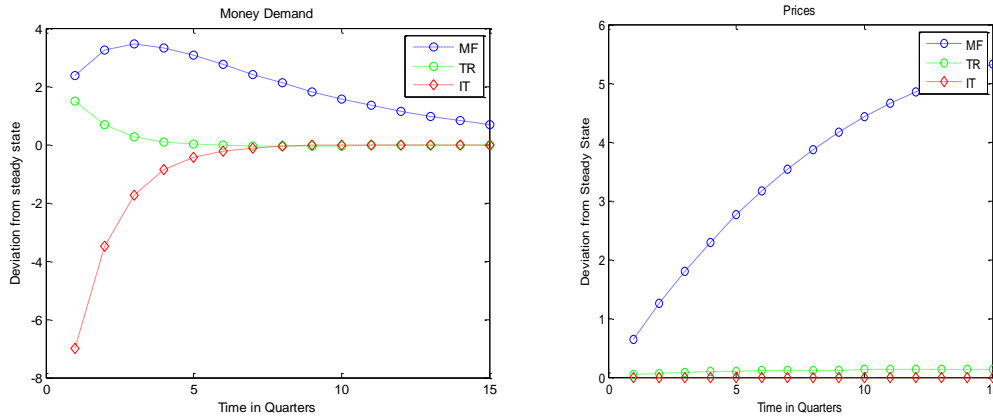
real rates leading to smaller costs of servicing the debt. With regards to welfare, it peaks at 2 percent at the very inception and subsequently tapers off slowly to zero. The pattern of this behavior is mainly explained by the paths of consumption (+) and employment (-).

Under debt-financing, inflation targeting pins down to zero output, consumption, welfare, employment, prices, and inflation. In order to reach these values the real and nominal interest rates climb to about 4 percent; thus money growth starts in negative territory. Under a standard Taylor rule, output, consumption, employment, welfare, money, and money demand present positive values, while inflation, price levels, nominal interest rate, and real interest rate are brought down to near zero. As opposed to money-financing, the debt ratio enters into positive values, obviously an unfavorable upshot. If one increases the coefficient in the Taylor rule, then the outcomes approach those with inflation targeting, as expected (not shown). With respect to the statistics in Table 1, they exhibit zero values under inflation targeting, while under a Taylor rule they may be misleading by construction, namely the trade-off ratio, which reveals “better” values than under a money financed option.

Figure 3: Effects of a Bonus Check (adjusted) over selected variables: Money vs. Debt Financing







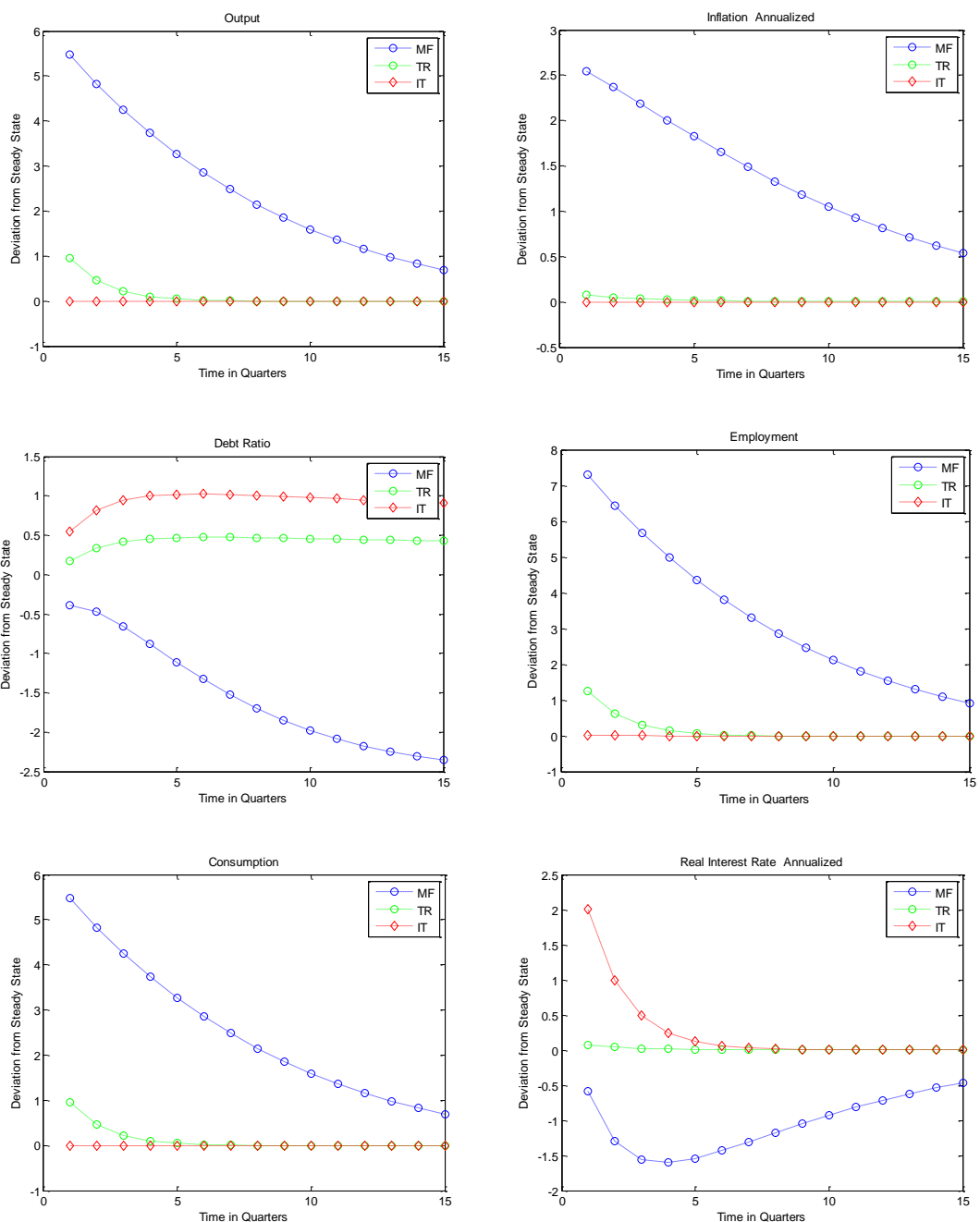
5.2 A “bonus check” with a shifter

Consider now a 1 percent increase in terms of output in government spending taking the form of a “bonus check” issued, unanticipatedly, to households. Bear in mind that under the assumption advanced, this instrument enters multiplicatively as a shifter in the households’ utility function and is treated as a stochastic shock. Hence the mechanisms of transmission and motion in this system are quite similar to those using what we labeled an adjusted “bonus check”. The key difference rests solely upon the other variables, all converging to a zero value steady state. The exceptions are obviously money and prices, particularly patent under money financing, which stabilize at 6% after several periods ($\lim p = \lim m \rightarrow \frac{V(=3)}{1-\rho(=0.5)}$).

Table 2 and Figure 4 below provide us with the two statistics being considered and the graphical depiction of some selected variables. The consumption multiplier and the trade-off ratio reveal positive values with money financing, albeit slightly lower; again care should be taken interpreting the latter under a Taylor rule. With money financing, real variables, such as output, employment, and welfare start at 5.5, 7.5, and 1.7, respectively, while annualized inflation stands at 2.5 in the first period, not quite different from the previous section, as expected. The same happens with most of the variables, though a reference should be made to the paths of the nominal scale of the impact on the consumption Euler equation, now lower, which filters through all and real interest rates under debt financing, namely inflation targeting. The monetary policy rule, with this definition, responds swiftly and lowers both rates by half from some 4% to about 2%.

	Dynamic Consumption Multiplier			Tradeoff Ratio		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
MF	5.48	11.13	18.75	8.61	7.89	7.06
DF-Taylor	0.95	0.92	0.89	48.73	35.62	26.95
DF-IT	0	0	0	0	0	0

Table 2: Effects of a Bonus Check with a shifter in a New Keynesian Economy: Money vs. Debt Financing



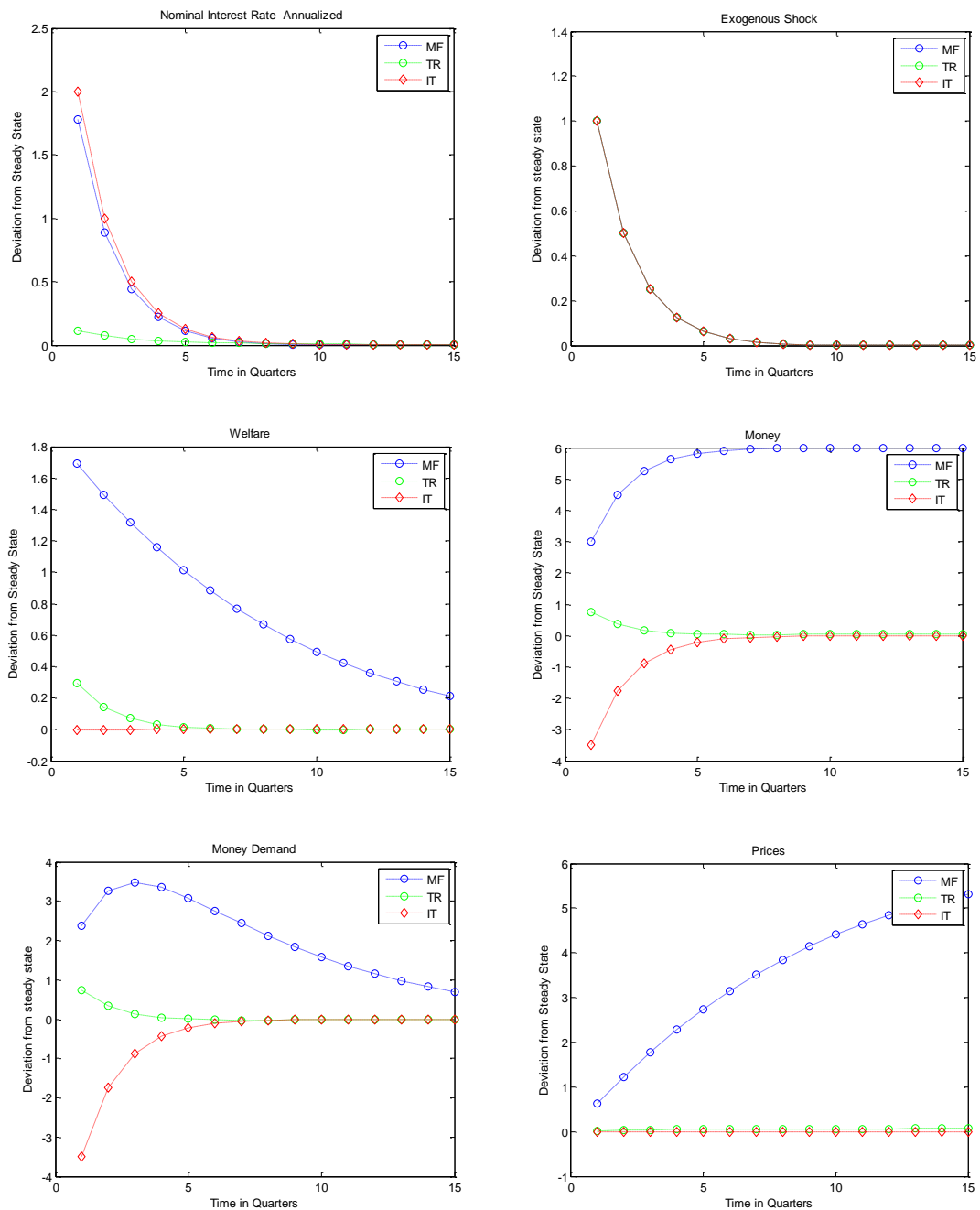


Figure 4: Effects of a Bonus Check with a Shifter over selected variables: Money vs. Debt Financing

5.3 A tax cut

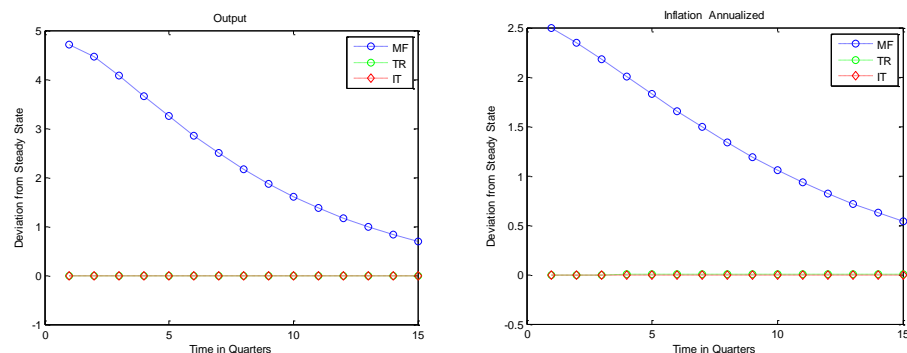
Consider now a decrease of taxes taking the form of a tax cut or a tax rebate. As in the previous two sections it is assumed that the cut is equivalent to 1 percent of output and follows an AR (1) process. As Figure 5 and Table 3 clearly show, a debt-financed tax cut simply has no effects on either real or nominal variables, the exceptions being the net debt ratio and taxes (the latter not shown). This neutrality can be

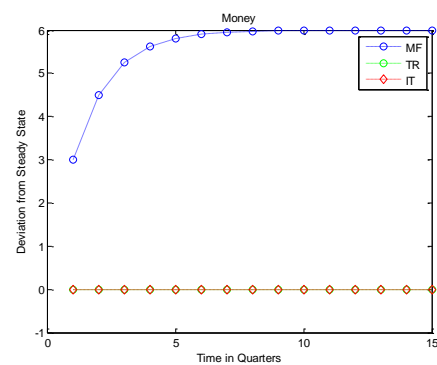
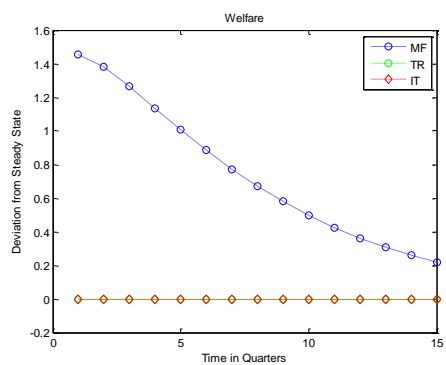
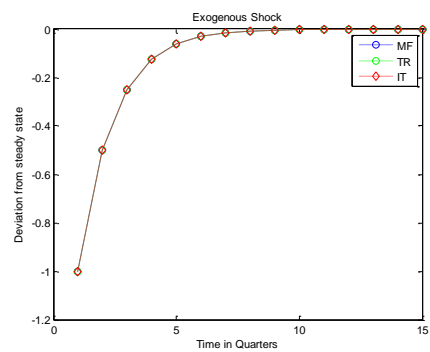
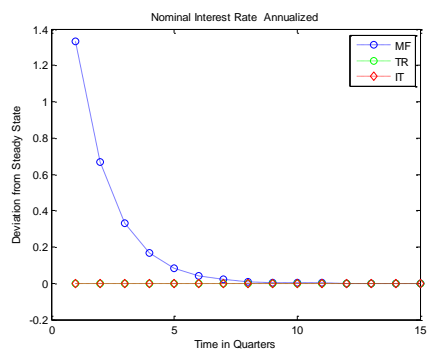
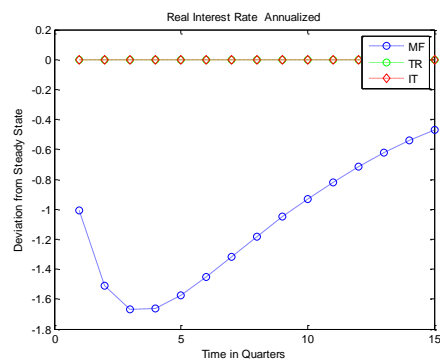
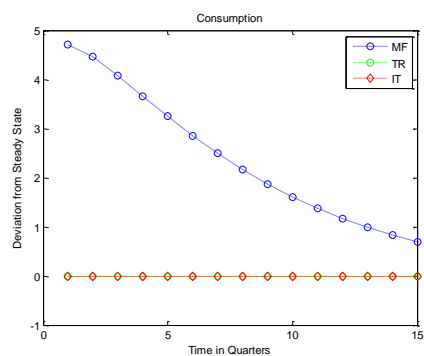
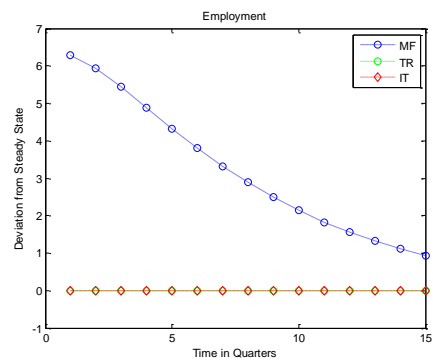
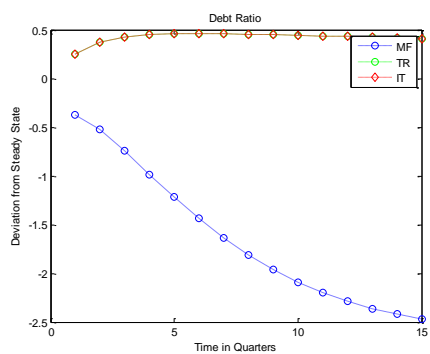
accounted for by the Ricardian equivalence. As we are assuming lump-sum taxes, the tax cut would be matched by future increases in taxation, leaving their present discounted value unchanged, while the household's intratemporal budget constraint remains unaffected. Moreover, note that, under debt-financing no other equilibrium condition is changed by the tax cut and the increase in the net debt ratio; all the other variables (nominal and real) remain the same.

However, the results are totally different if the tax cut is money financed. It leads to a substantial increase in economic activity. Negative real interest rates fuel consumption, which implies an increase in output and employment. Inflation also rises, following the shock, to an acceptable 2.5 percent but, thereafter, is bounded by the paths of prices and money as determined by nominal rigidities. Likewise, the nominal interest rate rise is bounded and reverts to zero by the fifth period, much faster than inflation, which lingers down more slowly. Indeed, to the extent that the discounted sum of real seignorage is raised by the tax cut and current prices do not spike to compensate that increase, current tax cuts may be interpreted as net wealth by the representative household, leading to an increase in consumption, which associated with nominal rigidities and given prices, will then elicit a variety of equilibria that can be interpreted as positive.

	Dynamic Consumption Multiplier			Tradeoff Ratio		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
MF	4.70	10.40	18.10	7.55	7.44	6.83
DF-Taylor	0	0	0	indeterminate	indeterminate	indeterminate
DF-IT	0	0	0	indeterminate	indeterminate	indeterminate

Table 3: Effects of a Tax Cut in a New Keynesian Economy: Money vs. Debt Financing





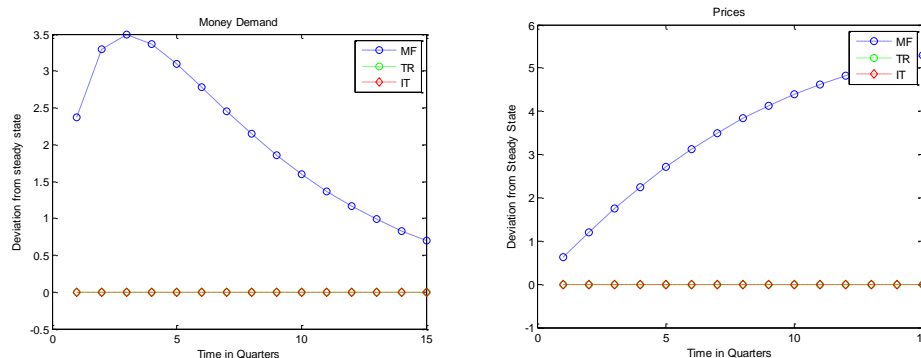


Figure 5: Effects of a Tax Cut over selected variables: Money vs. Debt Financing

5.4 An increase in government spending

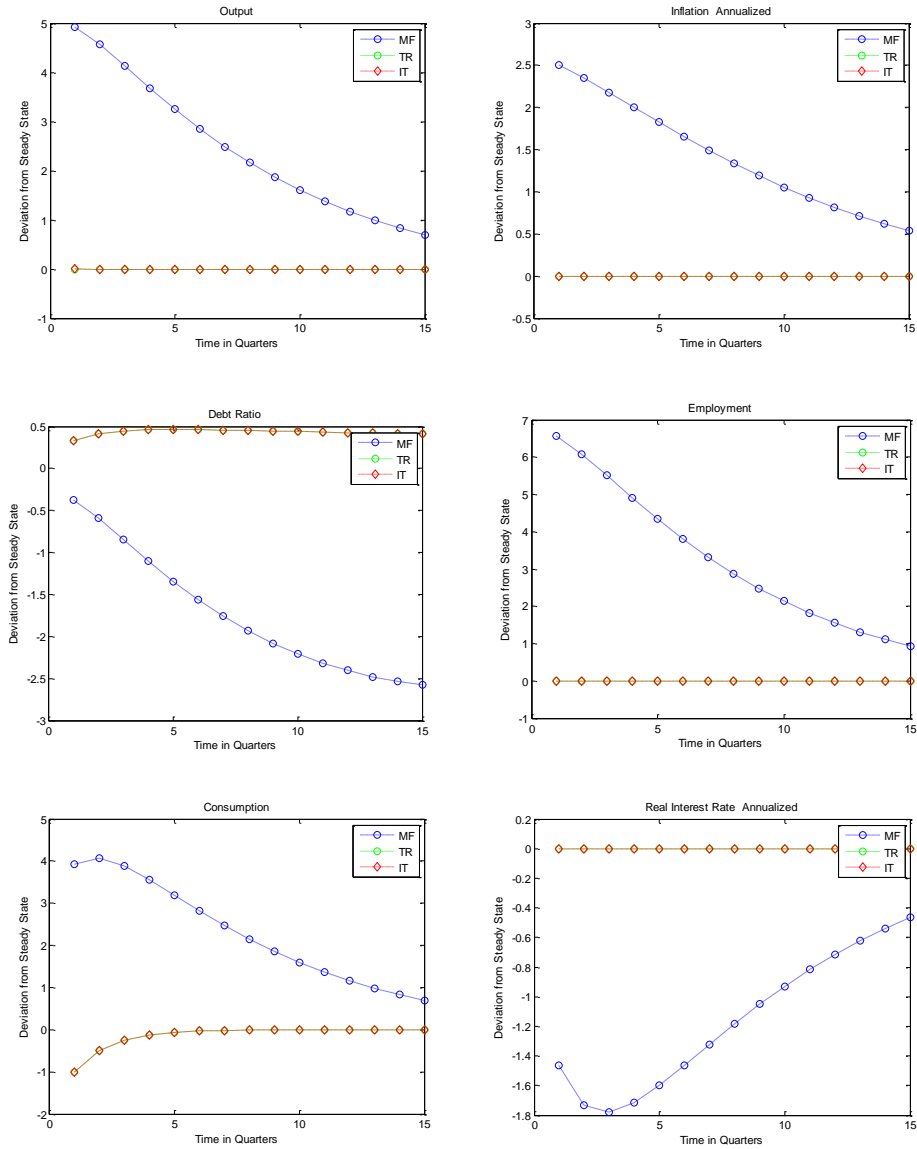
We will now assume a fiscal stimulus represented by an increase in government spending equivalent to 1 percent of output. No specific use is identified for this particular boost.

The results are shown in Table 4 and Figure 6 below. Under a seignorage process, similar dynamics as described for the other three stimuli take place. Nominal rigidities determine positive outcomes in terms of real variables, as there are interactions between real and nominal variables, as opposed to a frictionless setup. The latter, particularly inflation, the nominal interest rate, and the path of prices are also bounded, thus an increase in money filters through consumption, output, and welfare, while the net debt ratio evolves satisfactorily into negative ground, even though no specific use is assigned to fiscal spending. Theoretically it could be anything.

Under debt-financing, either using a Taylor rule or inflation targeting with the default parameters settings, the outcomes are identical. Several variables ranging from inflation, prices, nominal interest rate, and output are pinned down to zero. As government expenditures enter the equilibrium condition where, by definition, output is the sum of consumption and government expenditures, we have consumption following the path of the fiscal boost, but with a negative sign. Hence, the statistic *dynamic consumption multiplier* equals -1 throughout all the periods. The same applies, as expected, to other variables, particularly money, money demand, and welfare.

	Dynamic Consumption Multiplier			Tradeoff Ratio		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
MF	3.93	9.61	17.29	6.26	6.85	6.52
DF-Taylor	-1	-1	-1	∞	∞	∞
DF-IT	-1	-1	-1	∞	∞	∞

Table 4: Effects of an Increase in Government Spending in a New Keynesian Economy: Money vs. Debt Financing



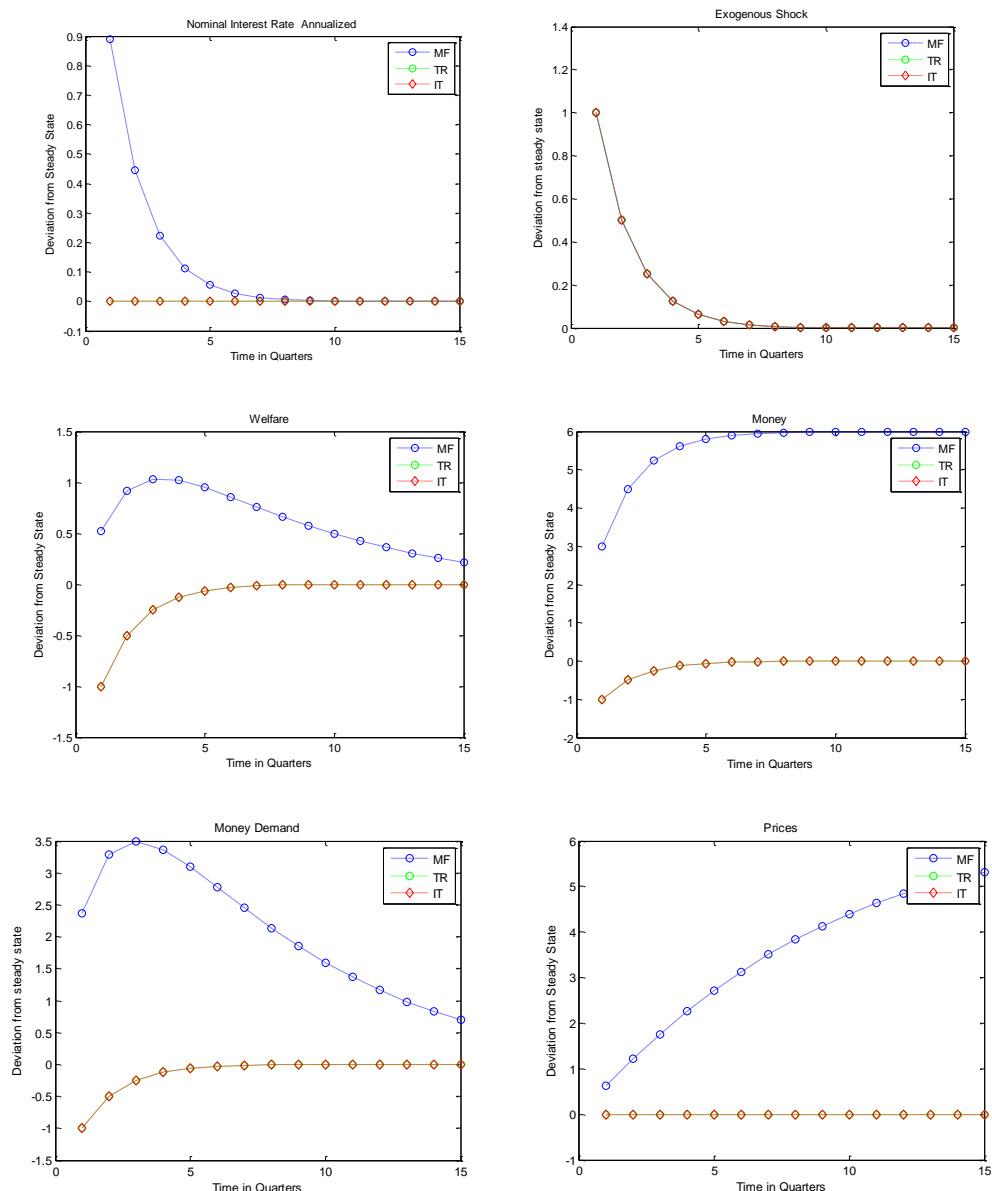


Figure 6: Effects of an increase in government spending over selected variables: Money vs. Debt Financing

5.5 Money-financed fiscal stimuli

In this section we compare across money-financed fiscal stimuli considering the two types of “bonus checks”, as well as a tax cut and an increase in government spending. The reason is simple: the results obtained suggest that overall, money-financed policies appear to be more effective than a debt-financed option. The outcomes of this particular experience are presented in Table 5 and Figure 5 below.

Let us then look at the Table 5, where it is inserted, for comparison purposes, a new statistic designated *dynamic welfare multiplier*, defined as

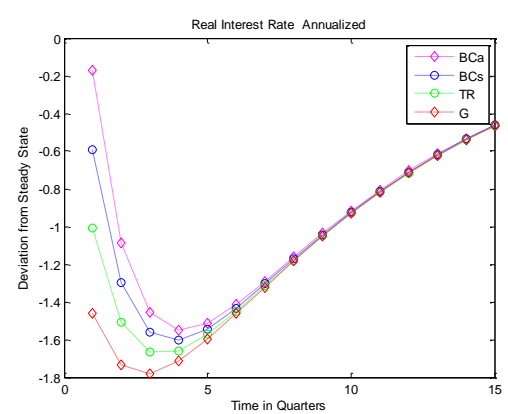
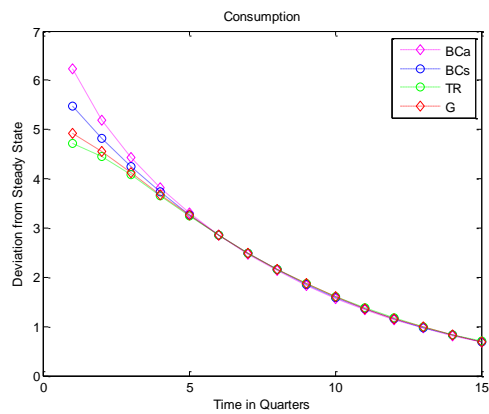
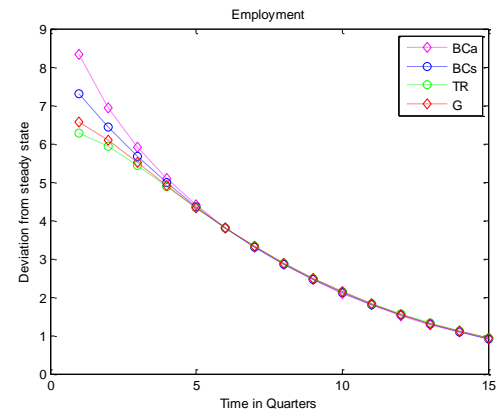
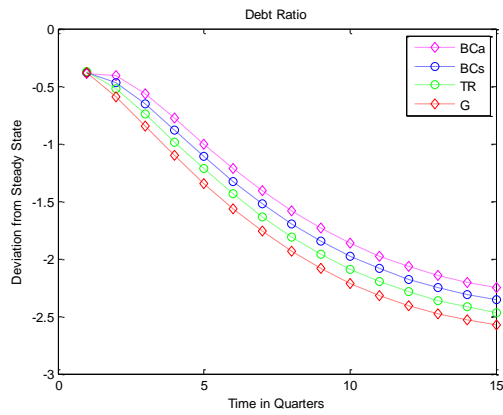
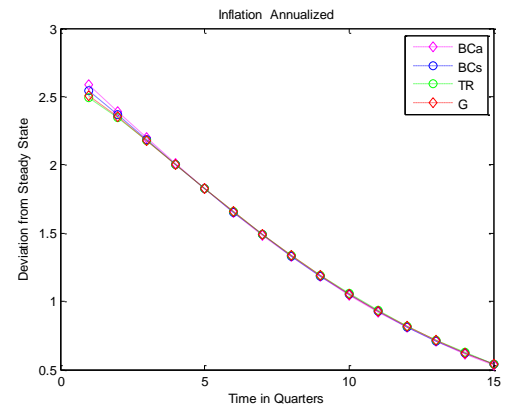
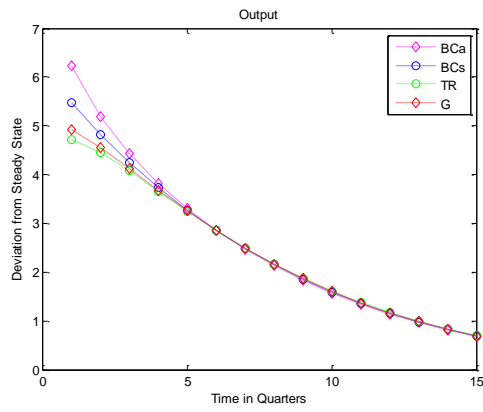
$$\Theta(k) = \left(\sum_{j=0}^k \frac{\partial_{wel_{t+j}}}{\partial_{\varepsilon_t}} \right) / \left(\sum_{j=0}^k \frac{\partial_{x_{t+j}}}{\partial_{\varepsilon_t}} \right) \quad (72), \quad k = 0, 1, 2, \dots \text{ and } x \text{ denotes type of fiscal}$$

stimulus. The numbers confirm positive outcomes and are actually not that far apart under the four different fiscal stimuli. They suggest a somewhat better “performance” with the issuance of “bonus checks”, namely in the first periods following the shock.

	Dynamic Consumption Multiplier			Tradeoff Ratio			Dynamic Welfare Multiplier		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
BCa	6.24	11.86	19.40	9.64	8.34	7.29	1.93	3.67	6.01
BCs	5.48	11.13	18.75	8.61	7.89	7.06	1.69	3.45	5.81
TR	4.70	10.40	18.10	7.55	7.44	6.83	1.46	3.22	5.61
G	3.93	9.61	17.29	6.26	6.85	6.52	0.53	2.28	4.67

Table 5: Effects of Money Financed Fiscal Stimuli in a New Keynesian Economy

The graphs of some selected variables corroborate these findings. Note that money growth, a multiple of the shocks, is identical under the four different stimuli, so is money supply, money demand, prices, and price inflation from the second period onwards. The key differences lie in the real variables such as output, consumption, employment, and welfare (if one discards the reduced effects of its monetary component), which exhibit differences in the first four to five periods as a result of how the shocks filter through the system of equations. Note, for instance, that taxes impact directly only upon money growth and the debt ratio (one might add the tax path, which is not shown). With respect to the interest rates, they respond to higher values in output as money demand is identical under the four scenarios. The difference in the paths of the debt ratios is mainly accounted for by the differences in the real interest rates over the first periods and its smooth and protracted (by construction) evolution towards its steady state at zero.



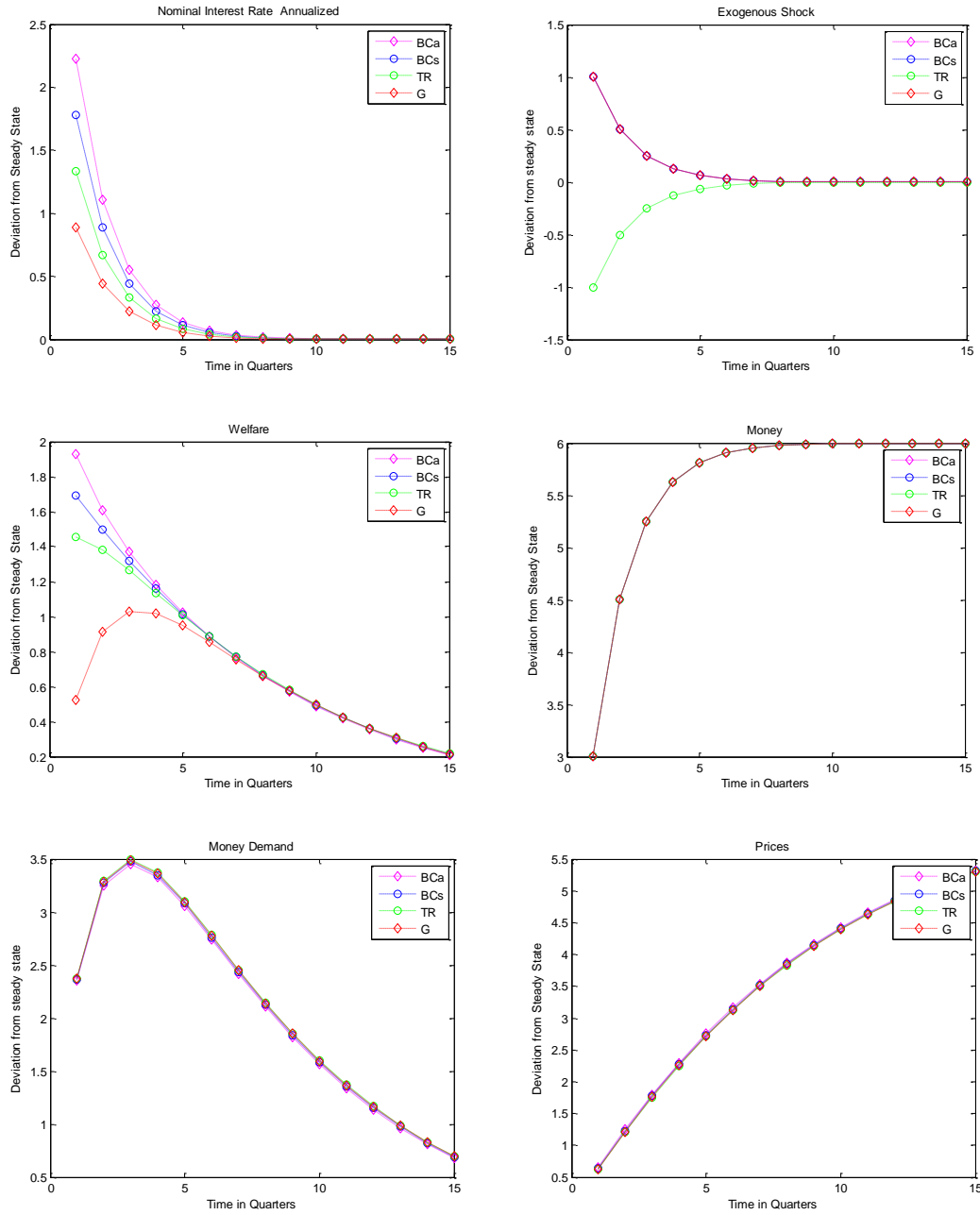


Figure 7: Effects of Money Financed Fiscal Stimuli

The results differ from those obtained by Galí (2017), which are much more subdued. Even though, the model specifications are slightly different (he does not consider nominal wage rigidities), the main explanation falls upon an assumption that he puts forward. The author considers a regime under which seignorage is designed in such a way that the real debt (B_t^H) remains unchanged. Specifically, for ease of reference recall equation (10) and assume, as implied, that $\widehat{b}_t^H = 0$.

$$\widehat{b}_t^H = (1 + \rho - \rho_b) \widehat{b}_{t-1}^H + b^h(1 + \rho)(\widehat{\iota}_{t-1} - \pi_t) + \widehat{g}_t - \widehat{t}^*_t - (1/V) \Delta m_t \quad (10)$$

$$\text{This means that } \Delta m_t = V [\widehat{g}_t - \widehat{t}^*_t + b^h(1 + \rho)(\widehat{\iota}_{t-1} - \pi_t)] \quad (73)$$

We use, instead the specification defined in (12a) and (15a); that is $\Delta m_t = V \widehat{g}_t = -V \widehat{t}^*_t$. Recall as well that, by definition, $V \widehat{g}_t = V \widehat{bcs}_t = V \widehat{bca}_t$. This means, as we have seen, that a money-financing regime leads to a fall in the net debt ratio and a higher impact on real variables, while a debt financing hypothesis determines an increase in the net debt ratio and hardly has any effect on real variables.

5.6 An experiment and sensitivity analysis

There are multiple options available to combine fiscal shocks with alternative financing regimes, more so, if one associates them with alternative parameter settings. For instance, a change in the level of persistence of the shocks, though not monotonic, has substantial effects on the variables. Other experiments were tried ranging from the interest rate semi elasticity of money demand (η), to the disutility of labor (φ), to the steady state debt ratio (b^h), to the elasticities of substitution ($\varepsilon_{p,w}$), to the endogenous component (ρ_b) of the tax path. The results and changes thereof, not shown, appear to corroborate the robustness of the qualitative findings presented above.

There are, however, two parameters particularly relevant for this analysis: the levels of price and wage stickiness (θ_p and θ_w , respectively). The significant differences, both quantitative and qualitative, in the responses to money-financed stimuli between the Classical and the New Keynesian setups are essentially explained by the presence of nominal frictions in the latter. In fact, by determining a gradual increase in prices, it entails a decrease in real rates, thus an increase in real variables, while the level of inflation is contained. A positive relationship between welfare (and the two other statistics adding regarding consumption and the trade-off ratio between consumption and inflation) and nominal rigidities holds. As an example, considering a practically frictionless state, say $\theta_p = \theta_w = 0.05$, corresponding to changes in prices and wages practically every period, it is found out that while the main predictions differ from those of the classical economy, they resemble in qualitative terms. In fact, using, for example, an increase in a government spending scheme, the impact on consumption

is small (1 percent at the most under money financing in the first period and zero from the third period onwards), independently of the financing regime, while the effect on inflation under money financing is also frontloaded and quite large (around 25 vs. 30 percent in a frictionless Classical model).

This reveals the relevance of correctly calibrating these parameters. Recall that we set as baseline calibrations the values (0.75) advanced by Galí (2014, 2017) who argues that these values are consistent with those in the literature. Tsuruga and Wake (2016) propose, as well, 0.75, as being consistent with those of Christiano *et al* (2005). However, more recently, Galí and Monacelli (2016) suggest a review to 0.80 striking a balance of estimates by several authors between 2001 and 2009; Christoffel *et al* (2008) advance with a domestic price rigidity calibration of 0.92 for the Euro area, which implies an average price duration over three years. English *et al* (2017) suggest that nominal price rigidities be set at 0.95, as representative for the USA in the recent recession.

Strictly for comparison purposes and to get a flavor for the relevance of these parameters, we ran two extreme assumptions, one with nominal rigidities set at 1, another set at 0.05 (slightly over zero) in order to get a closed solution. “The mathematics of the New Keynesian model do not allow that these parameters be set to 0”. The alternative is to use the Classical setup. The statistics are shown below (no graphs are depicted).

	Dynamic Consumption Multiplier			Tradeoff Ratio			Dynamic Welfare Multiplier		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
BCa	6.89	16.37	45.89	∞	∞	∞	2.13	5.07	14.23
BCs	6.11	15.59	45.11	∞	∞	∞	1.89	4.83	13.99
TR	5.33	14.82	44.33	∞	∞	∞	1.65	4.59	13.75
G	4.55	14.04	43.56	∞	∞	∞	0.72	3.66	12.82

Table 6: Effects of Four Different Money Financed Fiscal Stimuli in the New Keynesian Economy; Nominal Rigidities set at 1

This hypothesis, equivalent to the Old Keynesian Model, reveals “better” results when compared with the baseline calibration. Not only is inflation pinned down to zero, but real variables reach a new positive steady state by the 7th period, rather than converging to zero. For instance, output and consumption stabilize at 6 percent, corresponding to the full amount of the money increase, while nominal and real interest

rates exhibit the same motion falling to zero by the 7th period. The only upshot is an increase, albeit small, in the net debt ratio attributed to positive real rates in the first few periods.

	Consumption Dynamic Multiplier			Tradeoff Ratio			Welfare Dynamic Multiplier		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
BCa	1.13	0.63	0.60	0.25	0.20	0.20	0.36	0.19	0.18
BCs	0.99	0.56	0.54	0.21	0.18	0.18	0.30	0.17	0.16
TR	0.81	0.49	0.47	0.18	0.16	0.16	0.25	0.15	0.14
G	-0.14	-0.49	-0.51	-0.03	-0.16	-0.17	-0.74	-0.85	-0.85

Table 7: Effects of Four Different Money Financed Fiscal Stimuli in the New Keynesian Economy; Nominal Rigidities set at 0.05

The numbers clearly show that money financed fiscal stimuli under very low rigidities is not an option worth considering, with the exception maybe, of aiming to reduce the net debt ratio that is literally eaten away by a rampant, notwithstanding short-lived, inflation under these specifications. It also delivers a cautionary message to the implementation of such measures. In a long-run perspective these rigidities tend to be obliterated and may lead to incorrect perceptions or expectations by the economic agents.

6 Monetary policy in a liquidity trap

In this section we focus on the challenges faced by an optimizing monetary policy when confronted with a zero lower bound constraint on the nominal interest rate. In order to capture the liquidity trap, I assume, as in Galí (2017) a negative exogenous shock to the economy that brings down to negative terrain, on impact, not only the values of real variables but also those of monetary variables. There is, however, a limit in this scenario to how far can the nominal interest rate fall and that is zero, the so called zero lower bound. This description somewhat mimics what happened in the recent generalized financial recession.

Facing this framework how can the central bank react? For now, consider as shown by Jung *et al* (2005) that the traditional monetary policy without commitment is available and can be derived as a minimization process, leading to the following discretionary Taylor rule

$$i_t = \max (\log (\beta) + \rho, \phi \pi_t + \rho + z_t) \quad (74), \text{ where } z_t \text{ stands for the shock}$$

As an alternative, the optimal monetary policy under commitment assumes that the central bank can pursue a state contingent policy plan, which generally consists of actions that may be suboptimal ex-post, but whose anticipation may lead to a better policy tradeoff and welfare. This can be solved as a minimization process of a loss function by the central bank subject to the aggregate demand and Philips curves describing the economy, specifically the Central Bank seeks to minimize

Min $\sum_{t=0}^{\infty} \beta^t (\pi_t^2 + v \tilde{y}_t^2)$ (75), where v stands for the relative weight attributed to the output gap, subject to the sequence of constraints

$$\pi_t = \beta \pi_{t+1} + k \tilde{y}_t \quad (76) \text{ and } \tilde{y}_t = \tilde{y}_{t+1} - \frac{1}{\sigma} (\hat{r}_t - \pi_{t+1} - r_t^n) \quad (77)$$

where $k = \lambda (\sigma + \frac{\varphi + \alpha}{1 - \alpha})$ and $\lambda = (\frac{1 - \theta_p}{\theta_p}) (1 - \theta_p) (\frac{1 - \alpha}{1 - \alpha + \alpha \varepsilon_p})$

The solution to the associated Lagrangian is given by the following first order conditions

$$\pi_t = x_{i1t} - x_{i1t-1} - \frac{1}{\beta\sigma} x_{i2t-1} = 0 \quad (78), \text{ where } x_{i1t} \text{ and } x_{i2t} \text{ are the Lagrangian multipliers}$$

$$v \hat{x}_t - k x_{i1t} + x_{i2t} - \frac{1}{\beta} x_{i2t-1} = 0 \quad (79) \text{ and } \hat{r}_t \geq 0 \quad (80), \text{ and slackness conditions}$$

$$x_{i2t} \geq 0; x_{i2t} \hat{r}_t = 0, \text{ as well as initial conditions } x_{i1t-1} = x_{i2t-1} = 0$$

For additional details see Jung *et al* (2005).

For convenience purposes we label the set of the equations and conditions right above as describing a Taylor rule under commitment (TRC), while equation (74) is designated as a Taylor rule under discretion (TRD).

In addition to these rules, we will consider a possible coordination with fiscal authorities, covering possible fiscal stimuli in the form of a tax cut, an increase in government expenditures, including the issuance of “bonus checks”. They all take the form of a 1 percent unanticipated deterministic shock, if implemented, starting when the fall in the natural rate has occurred and lasting the same number of periods.

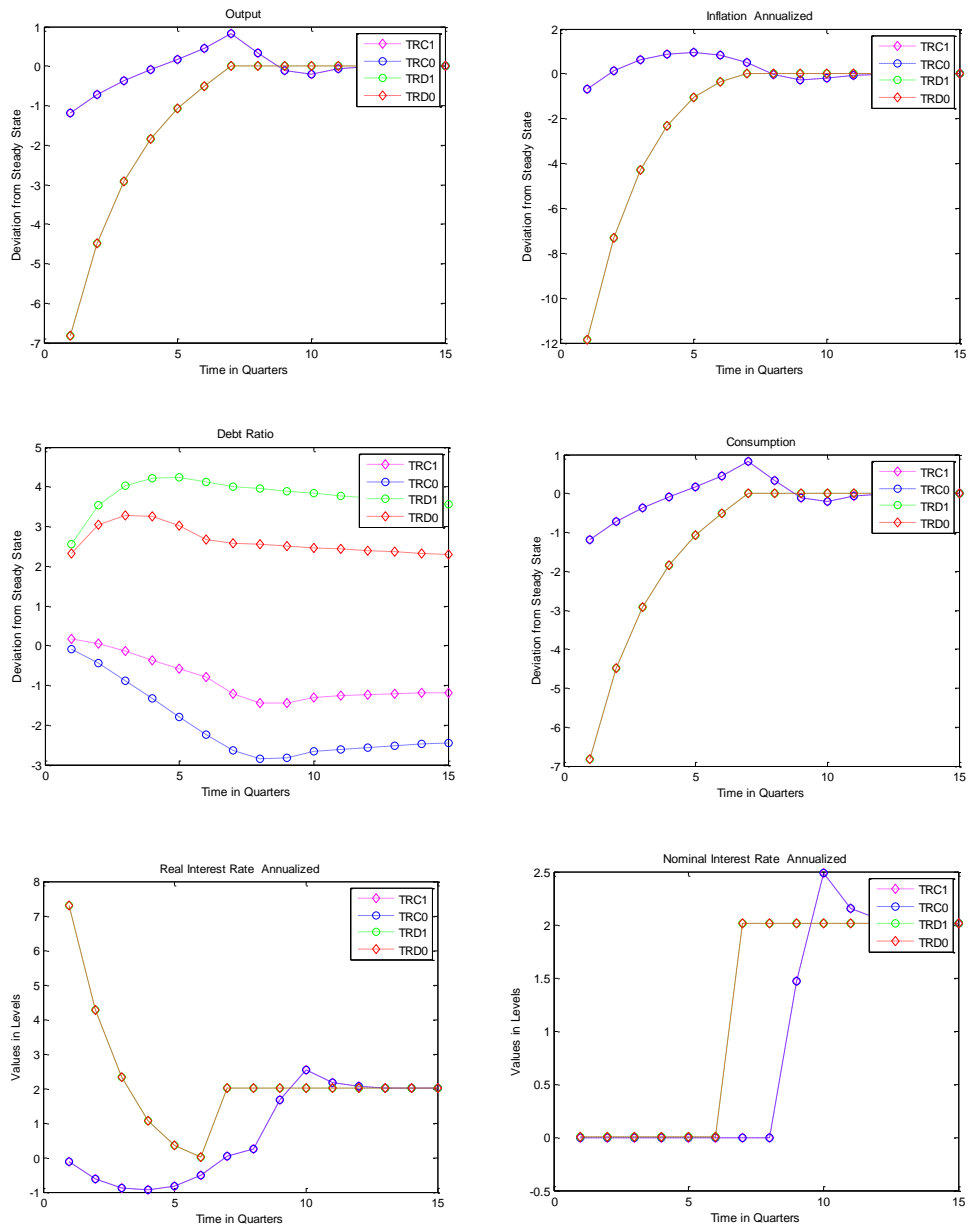
The results under a tax cut for some selected variables are shown below in Figure 8. Four possible scenarios are considered by combining the two alternative monetary policies (TRC and TRD) with the implementation or not of a tax cut, respectively 1 and 0. It is clear that this last hypothesis is irrelevant when implementing

the discretionary rule, as a tax cut, under this definition affects no variables, other than the net debt ratio and the tax path. Hence, real variables and inflation fall significantly into a negative domain following the exogenous shock, tapering off to zero, which is reached when the shock terminates. The nominal interest rate, expressed in levels, reflects the zero lower bound constraint. It remains at zero during the first six periods and then reverts to 2 percent, its steady state. The real interest rate in levels can be explained by the Fischer relation; it starts at a whopping +7 percent and stabilizes at 2 percent by the seventh period. This explains the path of the net debt ratio, which increases, even if there are no tax cuts. The path of the natural rate reflects the sequence of shocks; it falls to -2 percent for the first six periods and then jumps up to +2 percent.

A different whole story occurs under TRC, though, as before the values under TRC1 and TRC0 are identical. The behavior of real variables and inflation exhibit a smoother pattern and are contained, actually reaching positive ground before reaching a steady state at zero. Note that both money and prices move up and stabilize at around +1 percent, hence, money demand steady state converges to zero. However, money remains for the most part above the level of prices; this may suggest that some sort of money financed fiscal stimulus is in place. The explanation for the described behaviors falls upon the monetary policy under commitment, which is patent in the path of the nominal interest rate which remains at zero for a period longer than the duration of the shock; it then spikes up for one period before reaching the steady state at 2 percent in levels. This may be interpreted as forward guidance, as described by numerous authors, such as Eggertsson and Woodford (2013). This policy was pursued by several central banks in the recent past, as part of the unconventional monetary policies implemented under (or near) the liquidity trap. In practical terms, recall that forward guidance is a public commitment announced by the central bank to maintain short term interest rates low even after the end of the negative shock. The longer term spectrum of the interest rates can also be pursued through this commitment or the commitment to purchase (and/or actually purchase) long term securities. This is the other main tool of unconventional monetary policy (quantitative easing) still being implemented, at the time of writing, by some central banks.

If one were to select among these alternatives, the indicators obtained suggest that the adequate option might be TRC0; that is forward guidance without tax cuts,

based on the behavior of the net debt ratio. The absence of tax cuts and the negative values of the real interest rate expressed in deviation from the steady state (not shown) permit the net debt ratio to fall.



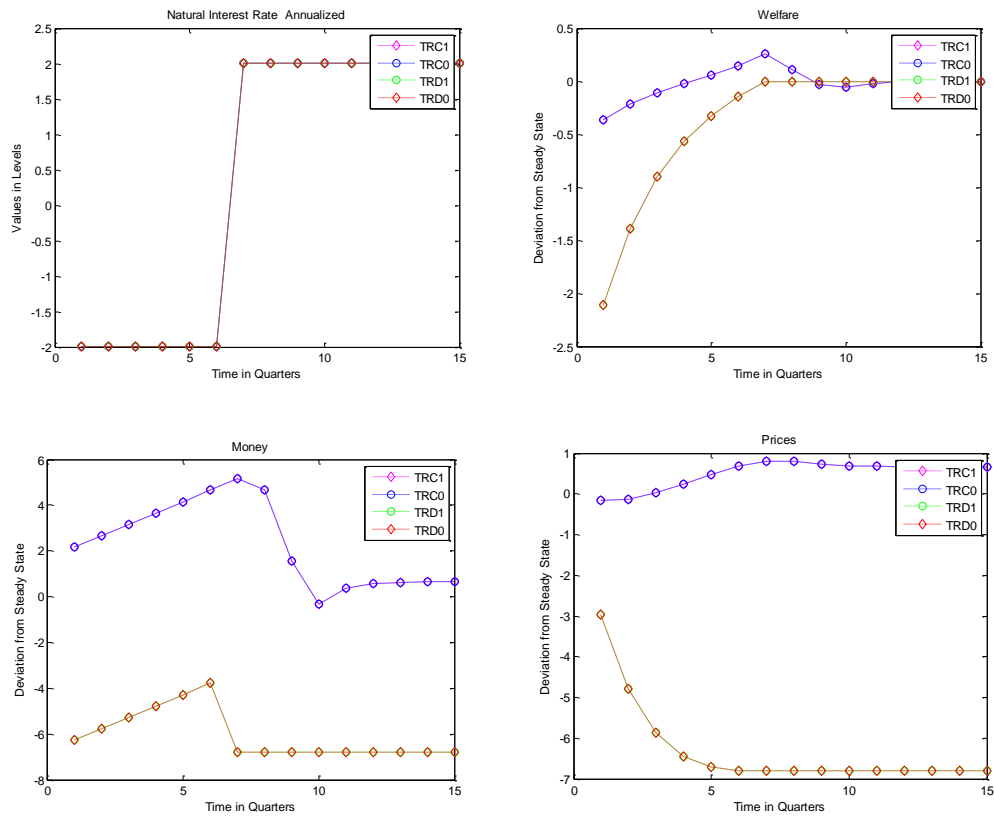
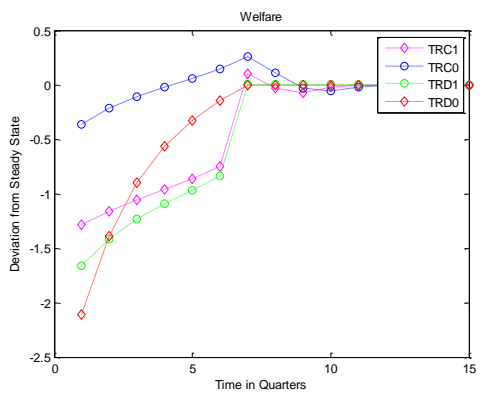
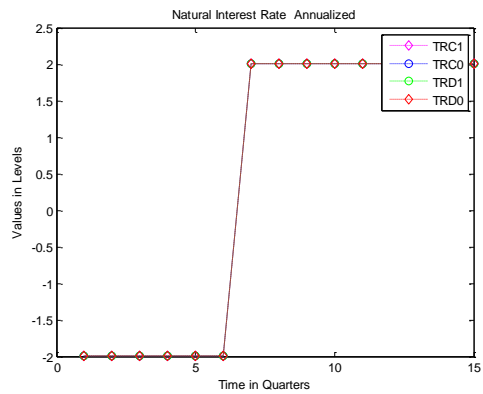
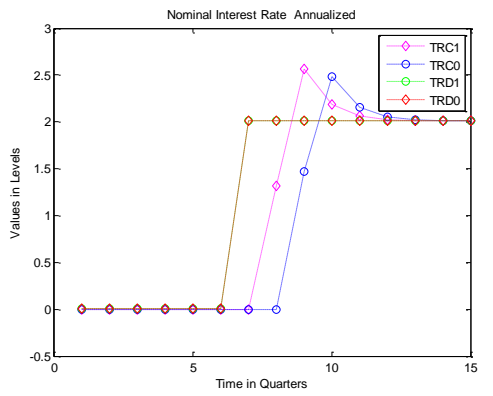
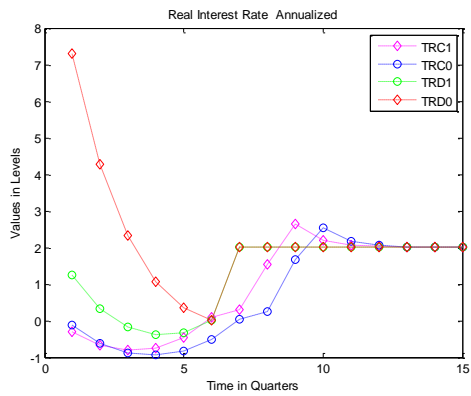
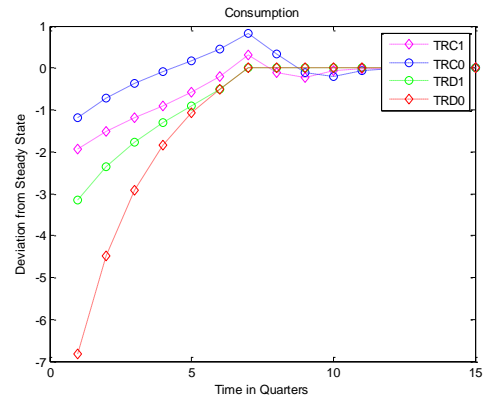
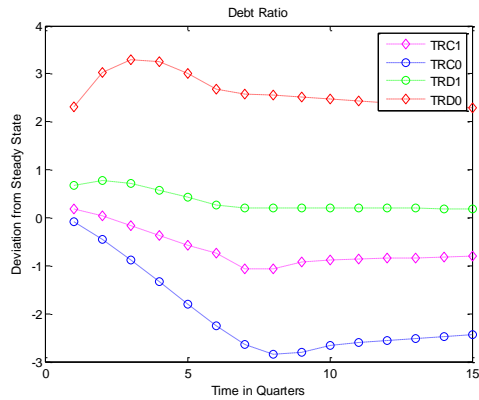
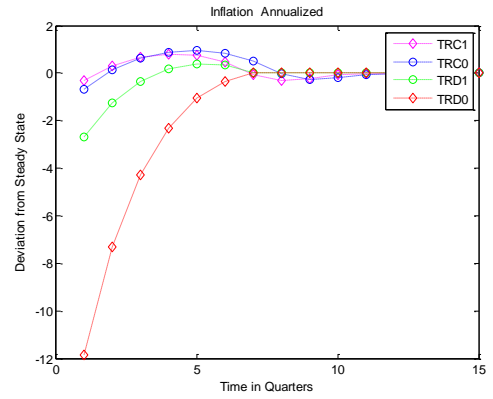
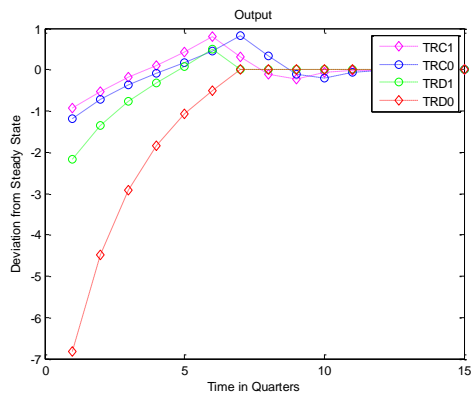


Figure 8: Effects of a Tax Cut under ZLB

Considering now an increase in government expenditures, figure 9 depicts the dynamics of several variables. As before, four different scenarios are presented.

Under TRD0 there are no differences between tax cut and government expenditures, simply because they do not occur. Under a TRD1, the outcome differs significantly as government expenditures enter in the equilibrium definition of the output. Thus, they do have an impact. Moreover, as there are no dampening effects by the monetary policy rule (the nominal interest rate is stuck at zero for the duration of the shock) real variables and inflation, though negative, reveal a behavior not far apart from those obtained with TRC.

If implementing a monetary policy under commitment, one arrives at slightly better outcomes, namely in terms of consumption and welfare (TRC1), which can be accounted from the equilibrium equation of output. The key explanation lies in the path of nominal interest rate. Again it remains at zero after the end of the shock, particularly if no expenditures take place. The overall graphs seem to indicate that the more appropriate choice might be TRC0, which combines a higher welfare and a lower debt ratio.



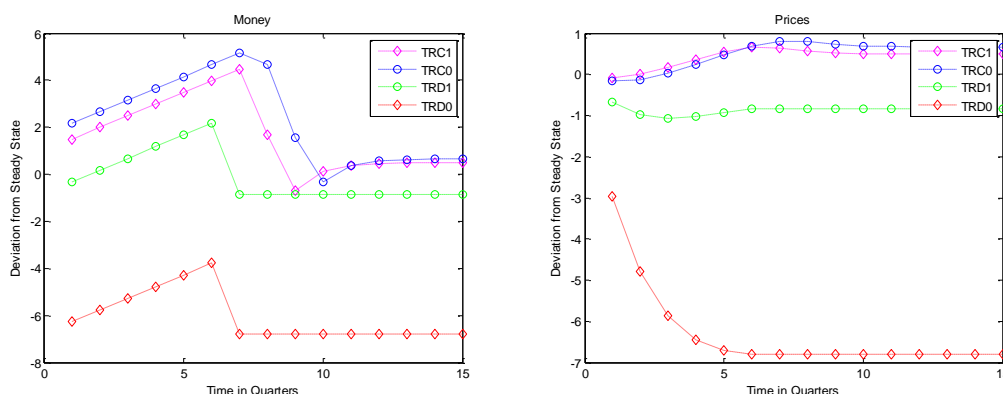


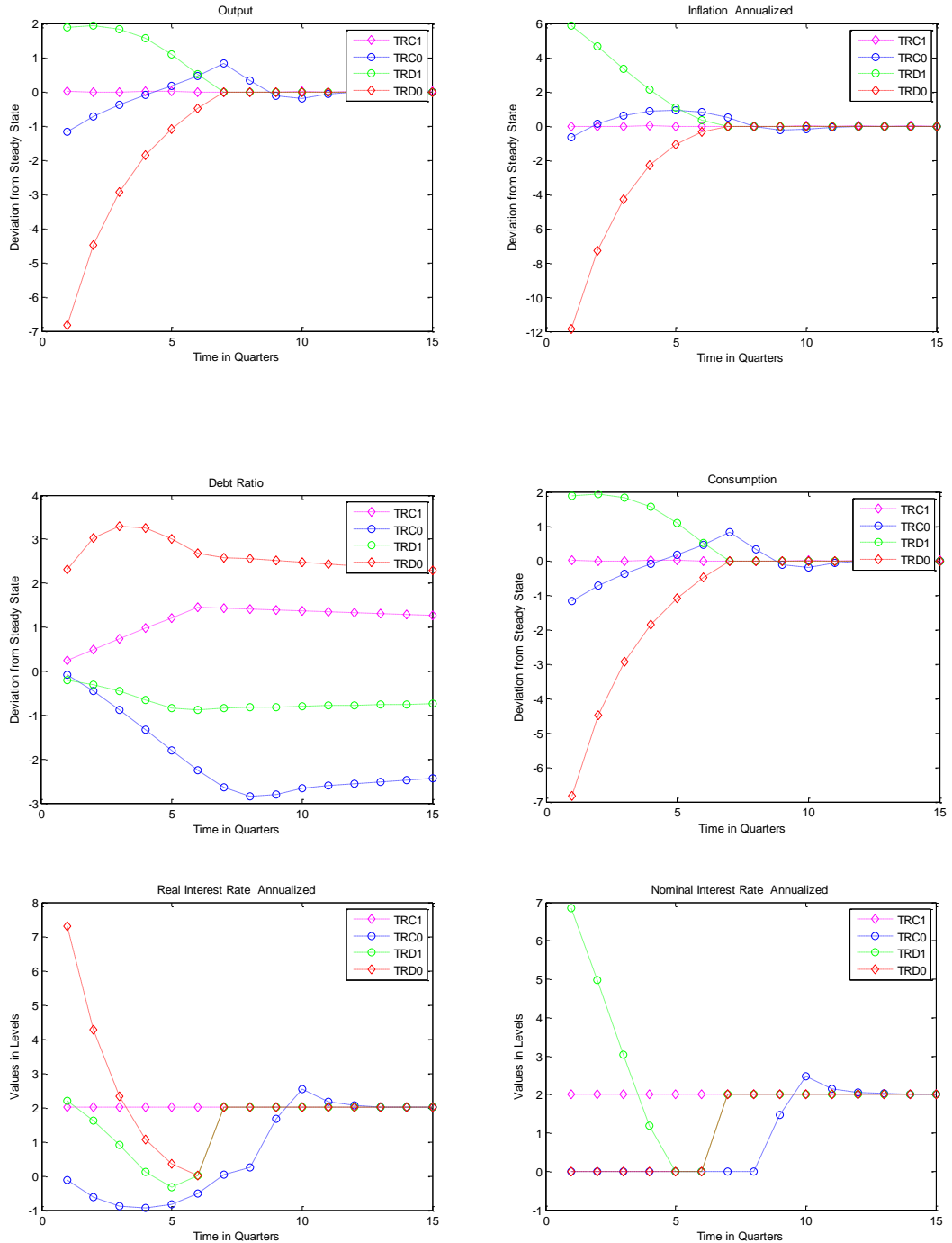
Figure 9: Effects of an increase in G under ZLB

Switching to the case of issuing “bonus checks”, please see Figure 10. Again we arrive at the same results with TRD0. However, under TRD1 the outcome is significantly different, the reason being that by definition both the “bonus checks” and the negative shock not only exhibit the same values with opposite signs, but also are specified as shifters to the utility function. Therefore, one is confronted with positive values for the real variables and inflation, though the tradeoff ratio statistic is clearly unfavorable. Additionally, the nominal interest rate is not bounded by the zero lower bound, as it designed to bring down inflation. It starts at 7 percent, and then falls down throughout the shock period, before converging to 2 percent. Another positive sign is the path of the net debt ratio explained by the increase in output and the negative values of the real interest rate, when expressed as a deviation from the steady state.

Under TRC, the results are somewhat in line with those obtained with an increase in government expenditures. When coupled with the issuance of “bonus checks” the negative effects of the exogenous shock are totally offset, with output, consumption, and welfare pinned down to zero right from the beginning. The cost is an increase in the net debt ratio. It would appear, considering this variable, as well as, the tradeoff ratio, and welfare that choosing TRC0 might be appropriate.

Reviewing the possibilities analyzed with respect to tax cuts, increase in government expenditures, and the issuance of “bonus checks”, one is tempted to argue that under a liquidity trap, the implementation of forward guidance as a package of unconventional monetary policy might have been the adequate solution, at least the second best, as advanced further ahead. In terms of sensitivity analysis, the model

appears to be robust. It is particularly sensitive to the size and duration of shocks and to the calibration of the nominal price rigidities, as it was the case outside the liquidity trap. Note that the baseline calibration (0.75) was used in this section.



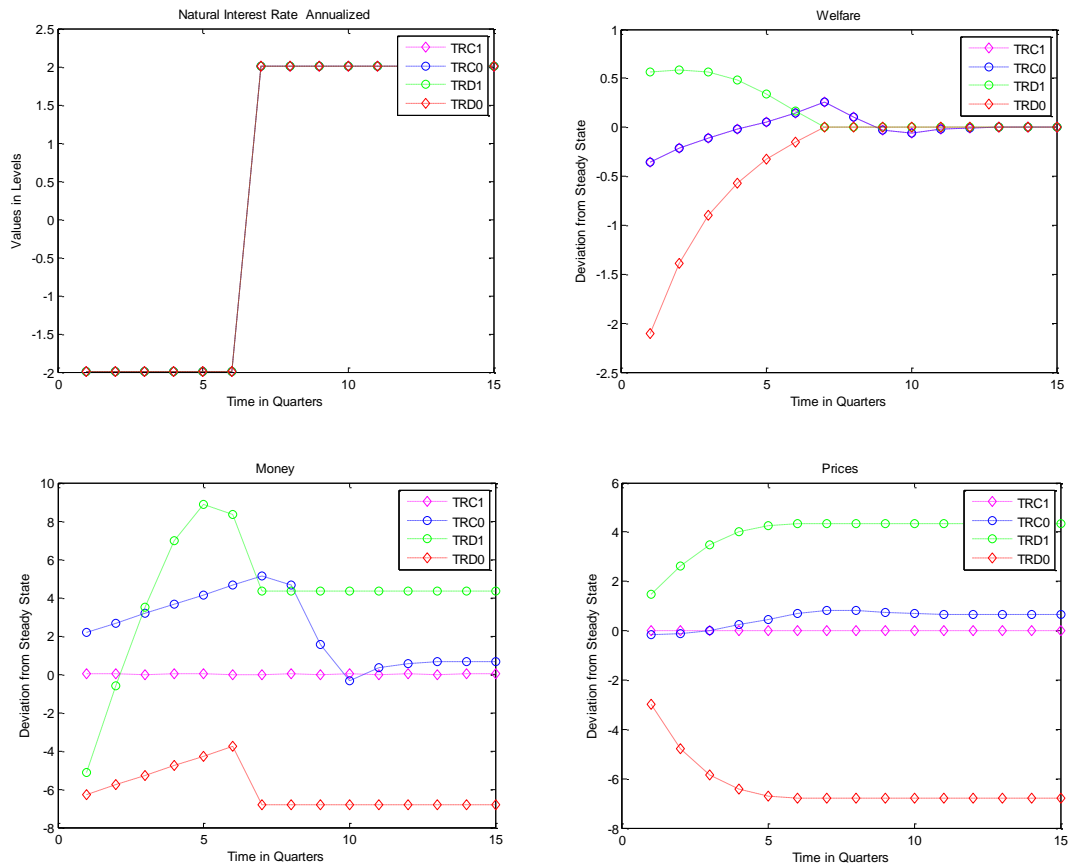


Figure 10: Effects of Issuing "Bonus Checks" under ZLB

7 Beyond the liquidity trap

In this section, following Goodfriend (2016) we advance the case for negative nominal interest rates in a framework where these rates are stuck at the zero lower bound. The study is complemented with the inclusion of fiscal stimuli. Additionally, we extend Galí's (2017) analysis by incorporating money-financed stimuli under a zero lower bound constraint.

7.1 The case for nominal negative interest rates

In the previous section we postulated that either a TRC or TRD lead to a second best solution, as the nominal interest rate was constrained by the zero lower bound. The idea that the first best would require nominal interest rates to track the path of the natural rate goes back many years ago and was advocated by Wicksell (1898). More

recently several authors, such as Goodfriend (2000, 2016), resuscitated this concern in an environment of secular stagnation advanced by academics like Summers (2016), who presents significant data to support this argument. For a more comprehensive survey and empirical evidence on this subject see Rachel and Smith's (2015) paper on the secular drivers of the global interest rate. They show that long term real interest rates in the developed world have fallen by some 450 basis points over the last three decades into near zero values and argue that the common driver is likely a fall in the natural real interest rate. This accounts for some 400 basis points of the downfall and they attribute it not only to a slower growth path, but particularly to shifts in savings and investment preferences. The former, so they say, is explained by demographic forces, shifts in income inequality and a glut of precautionary savings in emerging economies, while the latter may likely reflect a downward trend in the relative price of capital, lower public investment, and an increase in the spread between risk-free and actual interest rates. Furthermore, the authors suggest that these drivers may likely persist for a long period of time, thus, leading to a neutral real rate settling at or below the 1 percent level in the medium to long run. The consequences for the management of the business cycle may, therefore, be hampered, as they spell out, by the zero lower-bound.

Whether this hypothesis will prevail, remains to be seen. On the bright side and suggesting a possible different perspective see, for instance, Davies' (2018) article "Can secular stagnation morph into secular expansion?" in the [Financial Times](#).

Consider for instance, as described by Reifschneider (2016), the following monetary policy rule:

$$R(t) = R^* + \pi(t) + 0,5 [\pi(t) - \pi^*] - 2.0[U(t) - U^*] \quad (81)$$

where R is the federal funds rate, R^* is the longer-run normal value of the federal funds rate adjusted for inflation, π is the four quarter moving average of core PCE (personal consumption expenditures) inflation, π^* is the FOMC target for inflation (2 percent), U is the unemployment rate, and U^* is the longer-run normal rate of unemployment. Based on the median longer-run projections (March 2017) by the FOMC members, R^* is 1.4 percent and U^* is 4.8 percent. Therefore, with the unemployment rate reaching 10 percent and core PCE inflation falling to 1 percent in early 2009, the zenith of the US crisis, this rule would have called upon lowering the federal funds rate by over 8

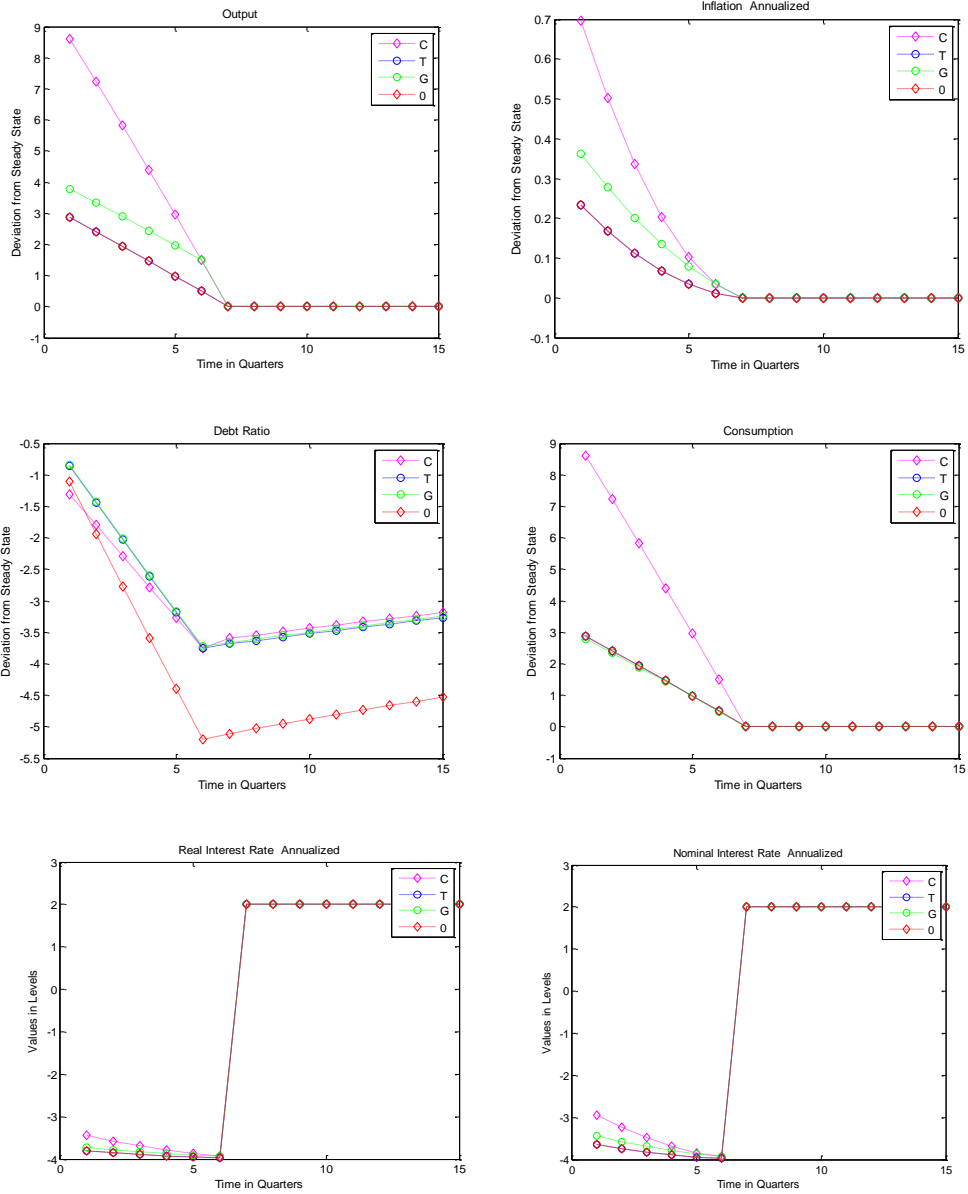
percent, a practical (and Fed legal issues aside) impossibility. According to the author this aggressive rule does a reasonably good job of accounting for the movements in the federal funds rate in the decade preceding its falling to its effective lower bound in December 2008. If instead, one uses the standard Taylor rule, which is half as responsive to gaps in resource utilization, the prescription would have been cutting the federal funds rate by a more modest, but still unfeasible, 3 to 4 percent below zero.

This raises the question: why not unencumber the interest rate zero lower-bound, in a similar way as the gold standard and the fixed exchange rate regimes were discontinued not that long ago, in order to better accommodate an independent monetary policy?

This is precisely the experiment that we will undertake, in a liquidity trap framework. Any advanced reference text book on monetary policy and the business cycle, such as Galí (2008), will clearly show that a negative shock to an interest rate Taylor rule under the dynamics associated will unambiguously translate into an increase in the real variables and inflation. The results are shown in Figure 11, which incorporates the usual negative shock (-1 percent) to the economy lasting for six periods associated with a negative shock to a simple Taylor rule (-1.5 percent) also lasting for six periods. In addition it is assumed a deterministic fiscal boost that may (or not) occur. Hence, we are dealing with four possible combinations that we label C (bonus check), T (tax cut), G (government expenditure) and 0 (no fiscal stimulus).

A quick glance at the graphs reveals that the variables display a rather linear behavior. This is explained by the existence of up to three simultaneous deterministic shocks. Furthermore, the outcomes in terms of real variables, inflation, net debt ratio, and the tradeoff ratio statistic appear to be desirable, particularly, by construction, with the issuance of “bonus checks”, followed by the increase of government expenditures. Under a tax cut, the outcomes are identical, as expected, to the one consisting simply of a reduction in the interest rate to a negative domain, the exception being, of course, the net debt ratio. Interest rates in levels, both nominal and real, fall to around -4 percent, as mentioned above and suggested by Reifschneider (2016) for the US in 2008-9, before returning to +2 percent. Mind you, that one is more interested in capturing the flavor of the relative dynamics, rather than the actual values; reality is far too complex to be represented by such a simple model.

The calibration used is the baseline, with the exception of nominal price rigidities. In this example we set it at 0.95, as recommended by English *et al* (2017) for a zero lower bound scenario. Should we use the baseline value (0.75), then the statistic tradeoff ratio would fall below unity, accompanied by a spike in inflation and the overall outcome would probably not be acceptable (graphs not shown).



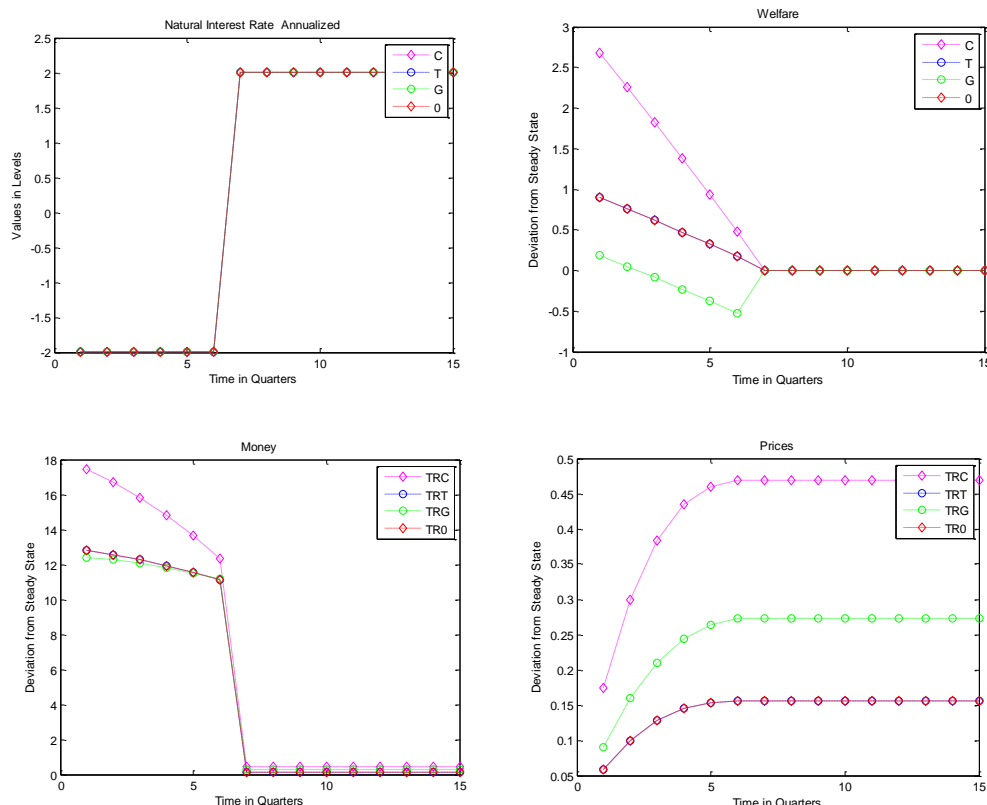


Figure 11: Effects of using a Taylor Rule coupled with fiscal stimuli to overcome a ZLB

Obviously, the implementation of these measures would call upon the unencumbering of the zero lower bound. Existing institutional arrangements, in which central banks accommodate the demand for paper currency at par for bank reserves and bank deposits, limit the extent to which a central bank can undertake negative interest rate policy. A sustained attempt to push short-term rates considerably negative would likely lead financial institutions and the public at large to exercise their option to exchange reserves and deposits for paper currency with severe consequences to the financial system. Handling and storage costs may deter such a switch provided that rates are slightly negative. Bernanke (2016) refers to studies by the Fed that place those costs in the vicinity of 35 basis points, somewhat above reference short-term rates in the Euro area, Switzerland, and Sweden, prevailing at that time.

Some solutions to bypass this state of affairs include the introduction of a tax on currency whenever paper currency is paid or received (Humphrey, 2016) or, alternatively, simply phasing out paper currency as studied by Rogoff (2014). True,

there are many arguments for not interfering with the status quo, ranging from the relevance of seignorage revenues to civil liberties arguments precluding “hopefully” tax evasion and illegal activity. But the fact is that the demand for cash currency continues to exhibit a large upwards trend in the two major currencies. See for instance Table 8

	US Total	US \$100	Euro Total	Euro > €50
2016	1463	1155	1126	1022
2015	1380	1082	1083	983
2014	1299	1014	1016	921
2013	1198	925	956	864
2012	1127	863	913	823
2011	1035	783	889	792
2010	942	705	839	756
2002	655	459	297	358
Δ % 2002/16	5.90	6.81	9.98	7.78

Table 8: Currency in circulation ([\\$](#) and [€](#)) as of year-end in billions. Source Fed and ECB

In the same period, nominal GDP grew on average by some 3.5 percent in the US and by 2.5 in the Euro area on an annual basis. Total currency as a fraction of GDP stood at 8 percent in the US and around 10 percent in the Euro area at the end of 2016. This may entail an eventual repudiation should a decision to abolish paper currency be contemplated. There are, however, alternatives to maintain paper money flowing while, simultaneously, bypass the problem of the zero bound on nominal rates.

Consider, for instance, setting up a flexible deposit (bank reserves) price of paper currency, where the central bank is available to exchange at par deposits and bank reserves; however, it would no longer print currency in order to allow the stock of cash currency to vary elastically to allow deposit (bank reserves) to be traded at par with paper currency. Furthermore, admit that in an environment of negative nominal interest rate policy actions, banks also pass the negative market interest rate to deposit rates; then, the deposit (bank reserves) price of paper currency would be driven above par to an equilibrium where this price is expected to fall back to par at a pace equal to the negative nominal market interest rate. Along this path, cash currency holders would be indifferent between holding deposits subject to a negative nominal interest rate, and holding physical currency whose value is expected to depreciate at an equivalent rate in terms of deposits (Goodfriend, 2016).

In practice, the deposit (bank reserves) price of paper currency would adjust flexibly in a similar pattern as floating exchange rates adjust according to a differential between domestic and foreign interest rates or, should one wish to eliminate other factors affecting exchange rates, as the forward exchange rate markets operate strictly dependent in the normal course of business upon the difference in interest rates. Authors such as Agarwal and Kimball (2015), Buiter (2010), and Kimball (2015) write at length in favor of a time varying exchange rate between deposits and cash currency; they actually move one step forward by advocating the implementation of a crawling peg policy by the central bank to prevent possible disruptions and ensure that the path of the exchange rate is coherent with the central bank's planned interest rate policy.

That said, it would appear that the conditions required for eliminating the zero lower-bound while maintaining the option to hold "hard" paper currency could possibly be met. Legal issues aside, such as allowing the payment of negative rates on bank reserves in the US or that contracts would henceforth be expressed in terms of deposit (electronic) currency, technology is to be made available to allow the smooth inexpensive flow of electronic currency. Rogoff (2014), in this regard, says that given the relentless technological progress we may already live in the twilight of the paper currency.

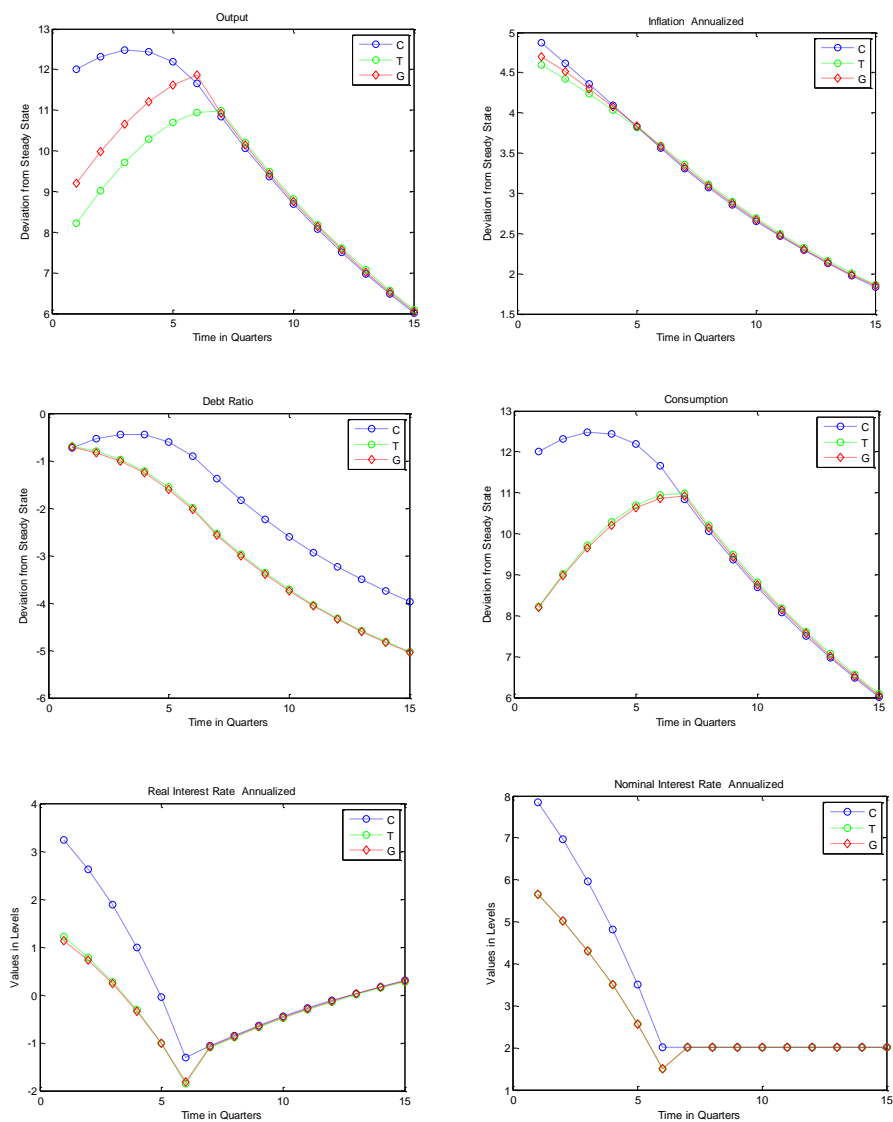
7.2- The case for money-financed stimuli in a liquidity trap

An alternative to the implementation of negative interest rates under a liquidity trap that may be worth considering is money-financed fiscal stimuli where money growth is a multiple of the stimulus. As in section 6, the unanticipated shocks once materialized follow a deterministic path (1 percent lasting for six periods, $t = 0, 1 \dots$). The results shown in Table 9 and Figure 11 below, suggest as well interesting effects. The increase in real variables is accompanied by a higher level of inflation (4.5 percent in the very first period), but the tradeoff ratio is significantly higher than unity. As in money financing without specifying a liquidity trap, the paths of money and prices are determinant for this evolution. Key for a more subdued growth in prices is the nominal prices rigidity set at 0.95. Again, if we simulate the nominal rigidity at 0.75, one is confronted with a whopping inflation rate in excess of 15 percent (annualized), the main

positive effect being the net debt ratio, which falls significantly. But, overall this would not likely be acceptable at all, at least for a central bank.

	Dynamic Consumption Multiplier			Tradeoff Ratio			Dynamic Welfare Multiplier		
	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14	k = 0	k = 4	k = 14
BC	12.01	12.28	24.52	9.86	11.28	12.28	3.71	3.80	7.60
TR	8.65	10.15	22.86	7.42	9.51	11.50	2.67	3.14	7.09
G	8.20	9.53	22.18	6.97	8.90	11.14	1.84	2.26	6.19

Table 9: Effects of Three Different Money Financed Fiscal Stimuli in the New Keynesian Economy under a Liquidity Trap; Nominal Rigidities set at 0.95



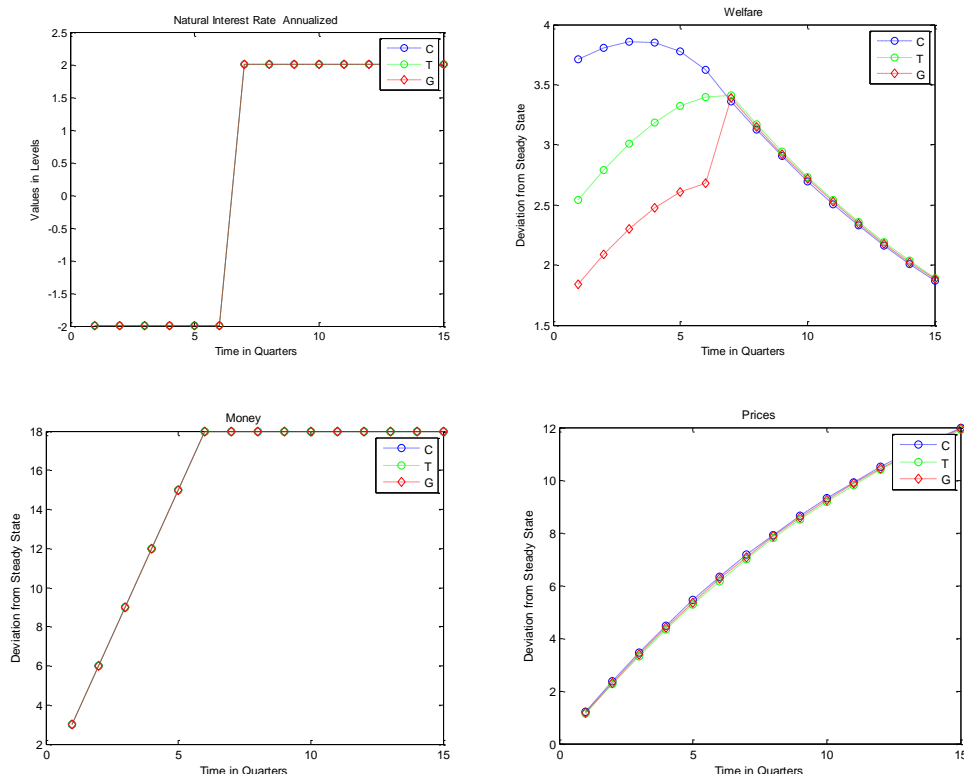


Figure 12: Effects of Money Financed Stimuli under a Liquidity Trap

7.3 The case for caution in a liquidity trap

In the previous two sub-sections, it was shown and particularly underlined that the success of the policies under analysis, hinges upon the level of nominal rigidities.

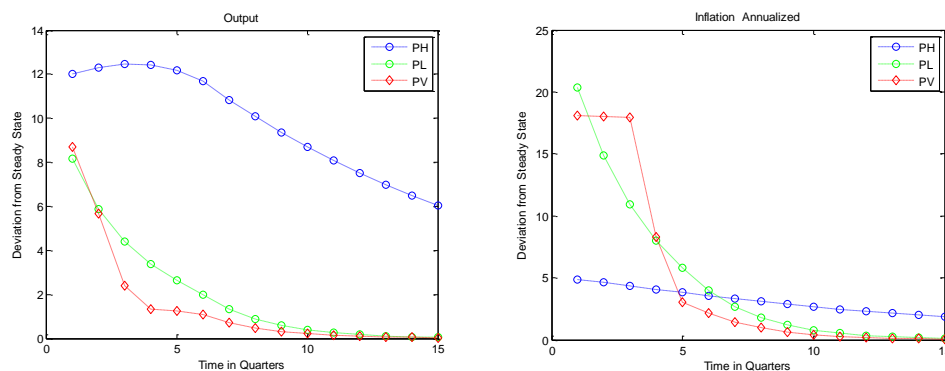
As money-financed fiscal program involves a large shift in the central bank's normal reaction function, achieving near-term output stimulus may be contingent on the public understanding the new strategy and accepting it as credible. It may likely be difficult to communicate the new strategy, which may possibly be perceived at variance with the objective of low and stable inflation that many central banks have adopted over the last three to four decades.

Moreover, in the presence of an increased money supply as well as of prices, the public may react by adjusting prices more frequently, in which case the main effect is a dramatic increase in inflation and a milder boost to output. In order to replicate this last hypothesis, the “nearest way” is simply consider alternative calibrations to nominal rigidities. Other authors call upon the concept of time varying parameters (see for example, Albertini and Lan, 2016). Indeed, parameters are subject to changes over time

and may actually suffer sudden structural shocks. The recent financial crisis is an example. One may consider as another example that following a significant negative disturbance with looming declines in output and prices, a representative agent may want to defer consumption in order to maximize utility, thus a higher beta, eventually larger than unity, conducive to a self-fulfilling prophecy of spiraling deflation.

There is a catch, however. In the process of linearization / Taylor approximation of the DSGE or DDSE model, parameters are assumed to be constant. Notwithstanding this caveat, it is depicted, for illustrative purposes only, in Figure 13, the graphs of some variables following the issuance of money financed bonus checks, with nominal rigidities set respectively at 0.95, 0.75 and finally exhibiting a time varying path: 0.95 for two periods, 0.50 for the next two periods, and henceforth 0.75. These different hypotheses are labeled PH, PL, and PV.

The visualization of the graphs, confirms that real variables still exhibit desirable growth, however not as high, under lower and time varying parameters; this comes at a high cost in terms of inflation reaching approximately the 20 percent platform, as the level of prices inch up faster. Again, one is faced with an interesting reduction in the net debt ratio accounted for a negative real interest rate. Similar dynamics take place (not shown), should one consider unencumbering the zero lower bound and use a possible less intrusive Taylor rule.



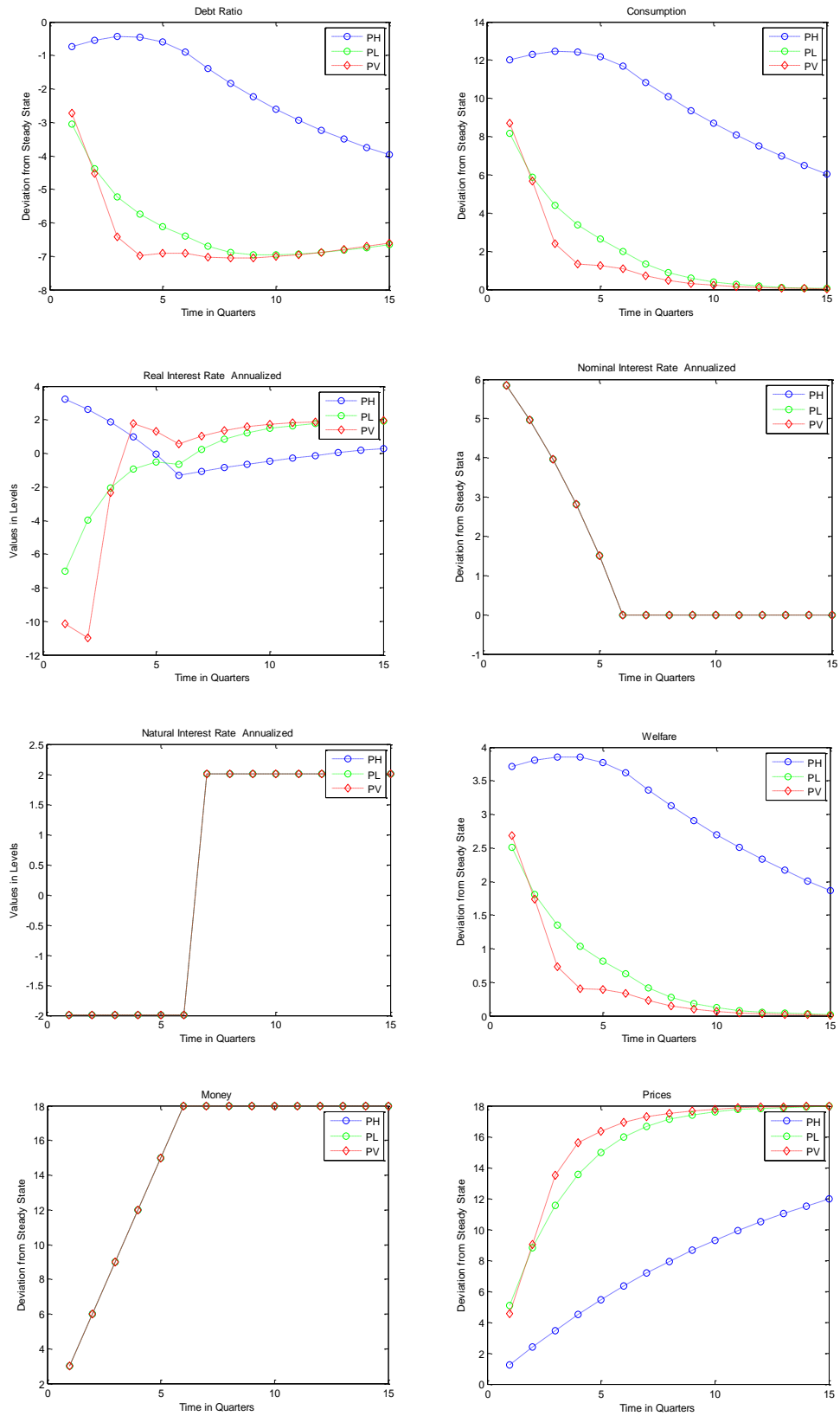


Figure 13: Effects of a Money Financed Stimulus under a Liquidity Trap and Different Nominal Rigidities

8 Final remarks and main conclusions

Early in the introduction, we mention Janet Yellen's (2016) intervention at a symposium on the subject "Designing Resilient Monetary Policy Frameworks for the Future", held in Wyoming in the United States on August 26th 2016. Indeed, what is at stake in this paper is to address how to possibly conduct monetary policy in the future. Though, following the Great Recession, unconventional monetary policy appears to have played, somewhat, a meaningful role in the process of economic recovery, though prospects by now appear to be generically brighter, some developed countries are still confronted with sputtering economies and levels of inflation below targeting. Moreover, ensuing the recession, many developed countries are also challenged with high levels of debt and an apparent irreconcilable path of loose money measures, in simultaneity with contractionary fiscal policy.

Consider as a hypothesis that a recession strikes again; after all, more than a decade is gone since the inception of the 2007 financial recession. What can monetary policy do in a scenario of low or relatively low interest rates, when there is no maneuverability space to bring them down? A possibility, as Yellen (2016) and Reifschneider (2016) advance is the continuation of the recently acquired policy tools. Another, as some authors argue, e.g., Goodfriend (2016) and Rogoff (2014), is bypassing the interest rate zero lower-bound calling upon the end of physical currency. One can also think of long-term interest rates capping, a practice followed after the World War II by the Fed and studied by Eichengreen and Garber (1991). This last hypothesis is not inside this paper's scope.

Instead, in this paper, we attempt to complement Buitter (2014) and particularly Galí's (2014) proposals of money financed fiscal stimuli by extending the types of stimuli (under a DSGE model) to encompass the issuance of "bonus checks" designed strictly to promote consumption under very specific conditions. It is my belief that this unorthodox proposition puts-off many authors and politicians, at least for the fear of inflation and a possible uncontrolled use of these measures; anyway, note that the implementation of quantitative easing and the massive injection of money into the economy generated some controversy and also putted-off many people. The main conclusions are the following.

a) A very stylized model was used in an attempt to capture the main drivers of a rather complex environment. Therefore, rather than to offer quantitative results, the intention rests upon eliciting a reasonable description of the dynamics involved. The main conclusion suggests that under adequate calibration of nominal rigidities, unanticipated money-financed stimuli, using any of the fiscal instruments coupled, obviously, with an agenda of cooperation between political (fiscal) and monetary authorities may lead to positive economic outcomes. Not only there is a boost to real variables, such as, consumption, output, employment, and welfare, but the associated cost represented by inflation is fairly contained and quite mild, while there may be a reduction of the net debt ratio. The effects appear to be more suitable in early stages, implementing additional consumption enhancing instruments. In the case of debt financing, it was shown that a central bank intervention under a mandate of economic stabilization literally eliminates the effects of a boost, but at cost of, generally, raising the net debt output ratio, with or without rigidities.

b) The choice of the values of nominal rigidities (or for that matter, ideally if possible, the actual values permeating the economy) is paramount in determining the level of success in implementing these measures. Indeed, there is a positive correlation between nominal rigidities and the level of success.

c) An experiment was performed, where nominal rigidities were considered to be unity, a limit hypothesis, conceivable in a very dire economic situation and large initial distortions. The results showed real variables reaching reasonably quickly a new steady state significantly above the initial zero steady state value. The price, however, is an increase in the net debt ratio. Lowering, even marginally, the level of rigidities annuls this cost and also leads to positive outcomes. High debt ratios may indeed be a major restraint in many developed economies. Hence, it may be advantageous (and possibly more realistic) to consider lower nominal rigidities, say in the 0.75 (the baseline calibration) to 0.95 range.

d) At the other extreme, considering an unlikely scenario of almost nonexistence of rigidities, under money financing the end result is a front-loaded spike in inflation bringing down, however, the net debt ratio through erosion; literally inflation eating away the debt overhang, if expressed in a currency controlled by the national central

bank. This hypothesis proxy the scenarios presented with a frictionless classical framework.

e) An experiment was conducted, following Gali (2017) and Jung *et al* (2005) to replicate a zero lower bound constraint following a negative shock to the economy. For this purpose the DSGE model was modified into a DDGE model incorporating unanticipated deterministic shocks. Should a central bank be restricted to interest rate rule it was argued that the use of a Taylor rule under commitment, which can be interpreted as forward guidance, delivered the best results, particularly, if one values the level of the net debt, without fiscal stimuli. This apparently is consistent with the unconventional monetary policies undertaken by central banks following the financial aftermath.

f) In addition, it was advanced that unencumbering the zero lower bound and implementing negative nominal interest rates associated with fiscal stimuli, namely in the form of “bonus checks” may lead to positive results and a low tradeoff ratio, provided that nominal rigidities remain high (in the vicinity of 0.90).

g) Considering money financed fiscal stimuli, as in the case of no zero lower bound restrictions, it leads as well to positive outcomes, particularly with “bonus checks”. To counter the effects of the negative shock, it is also needed a high level of rigidities; otherwise inflation may skyrocket.

h) This suggests that these measures, particularly in a liquidity trap, should be undertaken with caution. A comparison is made covering three possible scenarios. One consists of “high” frictions, another of “lower” frictions, and finally a time varying calibration of frictions, trying to capture the possibility that agents misunderstand the policies pursued and behave with fear of inflation, which eventually would be the end result. A possible alternative to counter the last two scenarios is the implementation of a prices and income policy.

Aside legal issues, the implementation of money financed fiscal programs, in practice, requires a close coordination between political and monetary authorities, which, in the long run, may eventually put at risk (or fear thereof) the central bank independence. Politicians may be tempted to use these instruments, when these actions are no longer adequate in macroeconomic terms. A possible setup is that through coordination, the creation and control of the funds, would be maintained under the

central bank jurisdiction; they would be made available when the monetary authority considered it necessary in order to achieve its goals in terms of employment (or output gap) and inflation. This may suggest that a central bank traditional reaction function that brings down nominal interest rate to negative domain may prove to be less intrusive, allowing it to trail negative natural rates, but also safeguard its independence.

Nevertheless, bear in mind that regular use of money financed policies, may quite possibly lead to an inflation bias and eventually be conducive to a human behavior that undercuts their effectiveness by lowering the nominal rigidities; on the other hand agents may simply refuse the elimination of paper money needed to pursue negative nominal interest rates, thus becoming a political issue.

A possible next venue of research in this area may focus on the possible restraints imposed by the financial system (in particular, Europe, where the bulk of financing is carried out by the banking sector as opposed to the US). Indeed, the aftermath of the Great Recession is still felt, at the time of writing, in the banking industry (for instance, in some European countries) in terms of a significant portfolio of non-performing assets and equity constraints. This may possibly explain the conceivable limitations in circulating money (lending rationing?), in spite of massive injections of money by the central bank. Should this be the case, then it may uphold the relevance of money financed stimuli in extreme circumstances. In the Euro area, however, such a policy may likely require the existence of a federal government in order to allow an agenda between the legislature and the monetary policy makers.

In a final analysis, what actually matters is the real fundamentals of an economy. But it is good to know that in (future) dire straits of economic duress, the monetary authority holds instruments that may be implemented. One may also consider in anticipation, the end of paper money.

References

- [Abreu](#), Alexandre, 2016, “Para as Mãos das Pessoas,” in *Expresso*, January 27th
- [Agarwal](#), Ruchir and Miles Kimball, 2015, “Breaking through the Zero Lower Bound,” IMF WP 15/224, pp. 1-39
- [Albertini](#), Julien and Hong Lan, 2016, “The Importance of Time-Varying Parameters in New Keynesian Models with Zero Lower Bound,” SFB 649, Humboldt University, Berlin, pp. 1- 56
- [Anderson](#), Derek, Benjamin Hunt, Stephen Snudden, 2014, “Fiscal Consolidation in the Euro Area: How Much Pain Can Structural Reforms Cause?” *Journal of Policy Modelling*, 36, pp. 785-799
- [Bernanke](#), Ben, 2016, “What Tools does the Fed have left? Part 3: Helicopter Money,” Brookings Institution, April 11, pp. 1-14
- [Bernanke](#), Ben, 2003, “Some Thoughts on Monetary Policy for Japan,” Remarks before the Japan Society of Monetary Economics, Tokyo, May 31, pp. 1-9
- [Buiter](#), Willem, 2014, “The Simple Analytics of Helicopter Money: Why it Works-Always,” *Economics E-Journal*, pp. 1-53
- [Buiter](#), Willem, 2010, “Three Ways to Overcome the Zero Lower Bound,” *North American Journal of Economics and Finance*, 20, pp. 213-238
- [Calvo](#), Guillermo, 1983, “Staggered Prices in a Utility-Maximization Framework,” *Journal of Monetary Economics*, 12, pp. 383-398
- [Christiano](#), Lawrence, Martin Eichenbaum, and Charles Evans, 2005, “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy,” *Journal of Political Economy*, 113, pp. 1-46
- [Christoffel](#), Kai, Gunter Coenen, and Anders Warne, 2008, “The New Area-Wide Model of the Euro Area,” *European Central Bank*, pp. 1-119
- [Davies](#), Gavyn, 2018, “Can Secular Stagnation Morph into Secular Expansion,” *Financial Times*, January 7
- [Eggertsson](#), Gauti, and Michael Woodford, 2003, “Zero Bound on Interest Rates and Optimal Monetary Policy,” *Brookings Papers on Economic Activity* 1, pp. 139-233
- [Eichengreen](#), Barry, and Peter Gerber, 1991, “Before the Accord: US Monetary-Financial Policy, 1945-1951,” *NBER Financial Markets and Financial Crises*, pp. 175-206
- [English](#), William, Christopher Erceg and David Lopez-Salido, 2017, “Money Financed Fiscal Programs: A Cautionary Tale,” *Hutchings Center WP* 31, pp. 1-47

- Friedman, Milton, 1969, "The Optimum Quantity of Money," Adeline Publishing Company, Chapter 1
- [Gali](#), Jordi, 2017, "The Effects of Money Financed Fiscal Stimulus," Revised, mimeo, pp. 1-40
- [Galí, Jordi](#), 2015, "Monetary Policy, Inflation, and the Business Cycle," Princeton University Press, Second Edition, pp. 279
- [Galí, Jordi](#), 2014, "[The](#) Effects of a Money Financed Fiscal Stimulus," SSRN DP 10165, pp. 1-50
- [Galí, Jordi](#), 2008, "Monetary Policy, Inflation, and the Business Cycle," Princeton University Press, pp. 203
- [Galí, Jordi](#), and Tommaso Monacelli, 2016, "Understanding the Gains from Wage Flexibility: The Exchange Rate Correction," NBER WP 22489, pp. 1-38
- [Giavazzi](#), Francesco, and Guido Tabellini, 2014, "How to Jumpstart the Eurozone Economy," Vox, pp. 1-5
- [Goodfriend](#), Marvin, 2016, "The Case for Unencumbering Interest Rate Policy at the Zero Bound," Paper Presented at a Symposium Sponsored by the FRB of Kansas, August 26th, pp. 1-38
- [Goodfriend](#), Marvin, 2000, "Overcoming the Zero Bound on Interest Rate Policy," Journal of Money, Credit and Banking, 32 4, Part 2: Monetary Policy in a Low-Inflation Environment, pp. 1007-1035
- [Humphrey](#), David, 2015, "Negative Interest Rates and the Demand for Cash," Florida State University, pp. 1- 12
- [Irwin](#), Neil, 2016, "Helicopter Money: Why some Economists are Talking about Dropping Money from the Sky," The New York Times, July 26
- [Jung](#), Taheun, Yuki Teranishi and Tsutomu Watanabe, 2005, "Optimal Monetary Policy at the Zero-Interest-Rate Bound," Journal of Money, Credit and Banking, 37-5, pp. 813-835
- [Kimball](#), Miles, 2015, "Negative Interest Rate as Conventional Monetary Policy," National Institute Economic Review, 234, November, pp. 1-14
- [Rachel](#), Lukasz, and Thomas Smith, 2015, "Secular Drivers of the Global Real Interest Rate," WP 571, Bank of England, pp. 1-63
- [Ramsey](#), Valerie, (2011), "Can Government Purchases Stimulate the Economy?" Journal of Economic Literature, 49-3, pp. 673-685
- [Reifschneider](#), David, 2016, "Gauging the Ability of the FOMC to Respond to Future Recessions," Finance and Economic Discussion Series 2016-068, Board of Governors of the Federal Reserve System, pp. 1-27

- [Reichelin](#), Lucrezia, Adair Turner, and Michael Woodford, 2013, “Helicopter Money as a Policy Option,” Vox, pp. 1-5
- [Rogoff](#), Kenneth, 2014, “Costs and Benefits to Phasing Out Paper Currency,” NBER Macroeconomics Annual 2014, 29, pp. 1-17
- Romer, David, 2011, “Advanced Macroeconomics,” McGraw-Hill, pp. 716
- [Sims](#), Christopher, 2016, “Fiscal Policy, Monetary Policy and Central Bank Independence,” Presentation at a Symposium Sponsored by the FRB of Kansas in Wyoming, August 26th, pp. 1-17
- [Summers](#), Lawrence, 2016, “Secular Stagnation and Monetary Policy,” FRB of St. Louis Review, Second Quarter 2016, pp. 93-110
- The [Economist](#), 2016, “Money from Heaven,” Print Edition April 21st
- [Tsuruga](#), Takayuki, and Shota Wake, 2016, “Money-Financed Fiscal Stimulus: The Effects of an Anticipated Shock,” WP Kyoto University, pp. 1-19
- Turner, Adair, 2017, “Between Debt and the Devil,” Princeton University Press, pp.314
- [Turner](#), Adair, 2015, “The Case for Monetary Finance: An Essentially Political Issue,” Presented at the 16th Jacques Pollack Annual Research Conference, November 5-6, pp. 1-54
- Walsh, Carl, 2010, “Monetary Policy and Theory,” MIT, pp. 611
- Wicksell, Knut, 1898, “Interest and Prices”, Reprinted by Sentry Press, 1962, pp. 374
- Woodford, Michael, 2003, “Interest and Prices,” Princeton University Press, pp. 785
- [Yellen](#), Janet, 2016, “The Federal Reserve’s Monetary Policy Toolkit: Past, Present, and Future,” Remarks Delivered at a Symposium Sponsored by the FRB of Kansas, August 26th, pp. 1-18

Chapter 5

Final Remarks

Final remarks

In Chapter 2, the main purpose was to advance with a simple relation to capture simultaneously the joint dynamics of the main unconventional tools used by the Fed. These policies were followed by an unprecedented increase in the Fed's balance sheet from some US\$900 million before the financial crisis to US \$4.5 trillion by the end of the large-scale asset purchases programs in October 2014. It was also shown that the change in assets, comprising mostly US Treasuries and mortgage-backed securities was matched by an increase in the liability side by base money, consisting of currency in circulation and, mainly, reserves. This explains why, in spite of reservations and fears aroused, the huge increase of base money did not materialize into inflation, quite the opposite. Fears of deflation, not only in the US, but also in the Euro area and in Japan loomed in the horizon. The answer, at least in the early stages, lies on the legacy of the 1970s and 1980s (Smith, 2016). The Great Inflation left scars on the psyches of those who experienced it; these people were in power during the Great Recession. As a curiosity, note that Ben Bernanke, who was at the helm of the Fed, between 2006 and 2014, is particularly interested in the study of the Great Depression. See, *e.g.* Smith (2016).

Reserves, indeed, are not included in standard measures of the money supply like M1 or M2 because unlike those measures, reserves are not directly available to the non-banking sector, and so are presumed not to affect economic activity. Reserves in excess of the regulatory requirements – excess reserves – may be lent out. To the extent that banks do lend out their excess reserves, they create deposits that add to the money supply and affect economic activity. If, as in the last few years, the financial system decides instead to sit on (some) those reserves and collect the interest that the Fed pays on excessive reserves, those funds will have no impact on the behavior of non-bank agents. While the financial system was severely hit by the Great Recession, this begs as a venue for further research, the study of possible motives that led to this particular behavior (consider, for instance, some European Union countries, nowadays), beyond the introduction of stricter capital and liquidity regulations. After all, more than a decade has gone by since the collapse of the subprime mortgage market.

From another perspective, the large amount of excess reserves and the possibility to remunerate them (the effective date of this authority in the US was October 1, 2008) introduced a new monetary tool made available to the Fed; similar powers have been granted to other major central banks. Traditionally, the Fed purchased or sold short-term Treasury securities in the open market to set its policy rate. This procedure is no longer required and was, in practical terms, replaced by the interest rate on excessive reserves (IOER) set by the Board of Governors, a more expedited process. The IOER is set to equal the top of the target range for the federal funds rate, as shown in Figure 1. Most likely, this new policy tool will be used for an extended period of time; but it requires a sizeable balance sheet.



Figure 1: Interest rate on excess reserves (IOER). Source: [Fred](#)

More recently, Debortoli et al (2018) corroborate the idea that both conventional and unconventional monetary share common goals and mechanisms. The title of the paper is fairly elucidative: “On the Empirical (Ir) Relevance of the Zero-Lower Bound Constraint”.

Chapter 3 presents an empirical essay, whose results appear to support the concept widely accepted by now that unconventional monetary policy has somehow fulfilled its objective. It is also broached the issue of downsizing the Fed’s balance sheet and entering into uncharted waters. Indeed, such a process has never been tried before by a central bank. The Fed stopped its buying spree in late 2014, but purposely refrained from shrinking its balance sheet until it was reasonably sure that the economy was good and ready. In this regard, Bernanke (2017) argues that there was no need to rush into initiating the unwinding process, until the policy rate was comfortably above the zero-floor, in order to counter possible misinterpretations by the markets, such as the significant fallout of May 2013, which earned the sobriquet in the financial markets:

“the taper tantrum”. That occasion occurred on September 20, 2017, when the Fed Chair, Janet Yellen and the rest of the FOMC decided to start reducing the Fed’s bond portfolio by starting off with small, monthly reductions of US \$6 billion of Treasury debt and \$4 billion of mortgage-backed securities. It was also decided to gradually increase that to a maximum of \$30 billion and \$20 billion, respectively. Rather than selling securities outright, bonds, as opposed to what had been the practice, will be allowed simply to “roll off”. The results of these decisions can be seen in Figure 2.



Figure 2: Fed total assets in millions of dollars. Source [Fred](#)

After the announcement, prices for shares and Treasuries’ yields rose slightly, but in retrospect, the reactions were seen as subdued; considering the enormous challenges that the Fed faces ahead. A possible interpretation is that the Fed’s unwinding had been widely signaled and expected to be very gradual. Furthermore, quantitative-easing programs were still being implemented by central banks in the Euro area and Japan; thus, the respective balance sheets continue to grow (not shown).

In respect to the question of how large should the Fed’s balance sheet be in the long run, Bernanke (2017) advances that there are reasonable arguments for keeping it large indefinitely, including the transmission of monetary policy to money markets, increasing the supply of safe short-term assets to market participants, and improving the central bank’s ability to provide liquidity during a crisis. He estimates that the optimal size of the Fed’s balance sheet is currently greater than \$2.5 trillion and may reach \$4 trillion or more over the next decade.

Quarles (2018), Fed’s Vice Chairman for Supervision, notes that there is not yet a decision by the FOMC as to the size of the balance sheet. A wide band is possible and he claims that this issue will not need to be decided for some time, and is dependent upon, e.g., the experience acquired through the gradual decrease in course and the

behavior of the economy. Figure 3 reproduces a graph in Quarles (2018), where liabilities stand for reserves held by the financial system, in order to meet the liquidity requirements in high-quality assets, which can consist (namely) of interchangeable US Treasuries and interest bearing deposits in the Fed. Thus, it is up to the management of each financial institution to decide its composition. Hence, Quale's uncertainty, about the level, in the future, of the Fed's balance sheet.

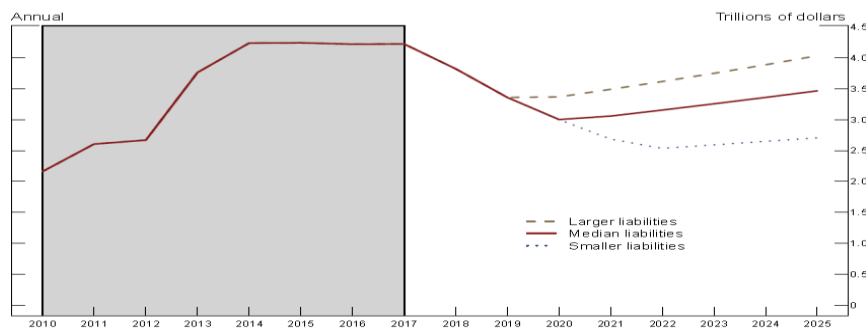


Figure 3: Projected SOMA (System Open Market Account) domestic securities holdings: Alternative Liabilities Scenarios. [Source](#): Federal Reserve Bank of New York

Note: Values are as of year-end and the shaded area represents actual figures. Smaller and larger liabilities are based, respectively, on the 25th percentile and 75th percentile responses to a question about the size and composition of the Fed's long-run balance sheet in Fed's (New York) survey of primary dealers and survey of market participants.

Harker (2018), President and CEO of the Federal Reserve Bank of Philadelphia, stated that the most important issue (in monetary policy) at the moment is that the new economic world we are entering may force policymakers to reevaluate their targets. Market interest rates have been trending downwards for years (secular stagnation hypothesis), starting long before the Great Recession and apparently continuing through the crisis and the current expansion. If it is the case that we are, in a low natural rate environment puts the Fed in something of a bind because it means that it is closer to the zero-lower bound. That is, the Fed cannot lower the policy rate much further than zero. So, if the natural rate is lower, the Fed has a smaller window in which to deploy rate moves. That, in turn, translates into less policy ammunition in the event of an expected turn of events, or, worse, a full-blown crisis. In the event that the hypothesis of a low natural rate proves to be correct it could be difficult to meet the inflation target, currently set at 2 percent. This may impact on inflation expectations and lead to one of Economics' idiosyncrasies: market expectations of low inflation can actually contribute to make it happen.

In such a scenario, we “... *would expect that the economics profession in general, and the Fed in particular, would debate them fully and equally* (the rethinking of monetary policy options). *Ultimately it is a question for the economics profession, and, if nothing else, I hope that the already substantial body of academic work gets even more robust.*” Harker, 2018, p. 5.

This is precisely what the essay in Chapter 4 tries to address. Admittedly, it is an unorthodox subject that may face serious reservations by policymakers and technocrats. Moreover, it should be approached with caution. But, as we have seen, so was unconventional monetary policy (Smith, 2016). However, one cannot say that money-financed fiscal stimuli have not been tried in the past. According to Lord Turner (2017), a staunch supporter of these policies, the US Union government printed greenbacks to pay for the war without generating dangerous inflationary side-effects during the American Civil War. In a similar fashion, the Japanese finance minister Takehashi used central bank funded deficits to pull successfully Japan’s economy out of depression in the early 1930s. There are, however, counterexamples, such as Weimar Germany, and modern Zimbabwe, which illustrate the dangers that once the option of printing money is first allowed, governments may print so much that they trigger hyperinflation.

The subject of money-financed stimuli calls for additional research, such as, exploring further the secular stagnation hypothesis and answer the questions: Are the technological innovations, over the last three to four decades, so deflationary that they may account for the decrease in interest rates? Do they generate income inequality and henceforth, a reduction in aggregate demand?

To conclude, we find it appropriate to quote Ben Bernanke.

“The deflation speech saddled me with the nickname ‘Helicopter Ben.’ In a discussion of hypothetical possibilities for combating deflation I mentioned an extreme tactic – a broad-based tax cut combined with money creation by the central bank to finance the cut. Milton Friedman had dubbed the approach a ‘helicopter drop’ of money. Dave Skidmore, the media relations officer...had advised me to delete the helicopter-drop metaphor...‘It’s just not the sort of thing a central banker says,’ he told me. I replied, ‘Everybody knows Milton Friedman said it.’ As it turned out, many Wall Street bond traders had apparently not delved deeply into Milton’s oeuvre.” (Ben Bernanke, 2015, p. 64).

References

- [Bernanke](#), Ben, 2017, “Shrinking the Fed’s Balance Sheet,” Brookings Institute Bernanke’s blog, January 27, pp. 1-11
- Bernanke, Ben, 2015, “The Courage to Act: A Memoir of a Crisis and its Aftermath Shocks,” W.W. Norton & Company, pp. 600
- [Debortoli](#), Davide, Jordi Galí, and Luca Gambetti, 2018, “On the Empirical (Ir)Relevance of the Zero Lower Bound Constraint,” Barcelona GSE WP 1013, pp. 1-25
- [Federal](#) Reserve, 2017, “FOMC Statement on September 20,”
- [Harker](#), Patrick, 2018, “Keynote Address: The Economic Outlook,” Speech at Central Bucks Chamber of Commerce, January 12, Ivyland, Pennsylvania, pp. 1- 5
- [Quarles](#), Randall, 2018,” Liquidity Regulation and the Size of the Fed’s Balance Sheet,” Remarks delivered at a Hoover Institution Monetary Policy Conference, Stanford University, May 4, pp. 1- 15
- [Smith](#), Noah, 2016, “Ben Bernanke’s The Courage to Act: A Review Essay,” International Finance, 19 1, pp. 108-118
- Turner, Lord Adair, 2017, “Between Debt and the Devil,” Princeton University Press, pp. 314